FASTEN YOUR SEATBELTS AND PREPARE FOR A VOYAGE TO THE WILDER OUTER FRINGES OF SCIENCE – WITHOUT LEAVING YOUR KITCHEN OR BACK GARDEN.

Sean Connolly's *Wholly Irresponsible Science* – which brings together material from his two previous bestselling *Wholly Irresponsible* books – presents 120 scientific experiments which keep the dangerous bits in.

Create your own weather system, re-animate 'Frankenstein's hand', overcome gravity, build a matchbox microphone and much more.

With its quirky experiments, eye-catching design and witty yet informative text, it's the perfect hands-on introduction to the principles of science. It's utterly addictive science, whether you're ten years old or just sometimes feel you'd prefer to be.

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WHOLLY IRRESPONSIBLE SCIENCE!

ADULT SUPERVISION NEEDED

[illegible]

120 DARING EXPERIMENTS TO DO IN YOUR HOME AND GARDEN

SEAN CONNOLLY

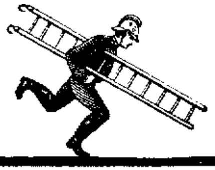
SEAN CONNOLLY will be familiar to listeners of BBC Radio Five Live and Radio Wales. Among his more than 50 books aimed at children and adults are *In Time of Need: Storms and Earthquakes* and *Witness to History: The Industrial Revolution*. He's also written for the *Kingfisher Science Encyclopedia*. His three children are either collaborators or guinea pigs, depending on the project.

WHOLLY IRRESPONSIBLE SCIENCE!

120 DARING EXPERIMENTS TO DO IN YOUR HOME AND GARDEN

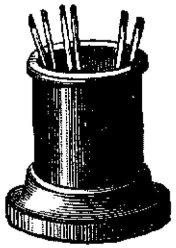
SEAN CONNOLLY

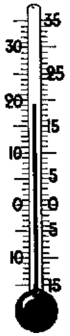
ICON BOOKS



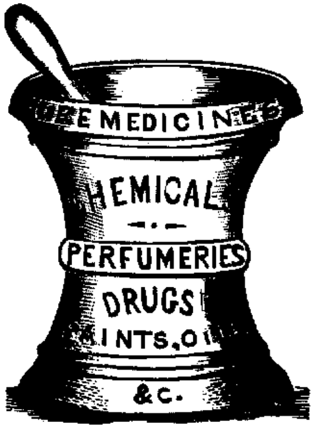
ADULT SUPERVISION NEEDED

These experiments involve matches, hot liquids and ingredients that could be harmful if used incorrectly





To my fellow travellers on this stage of a wonderful journey – Frederika, Jamie, Anna, Thomas and Dafydd



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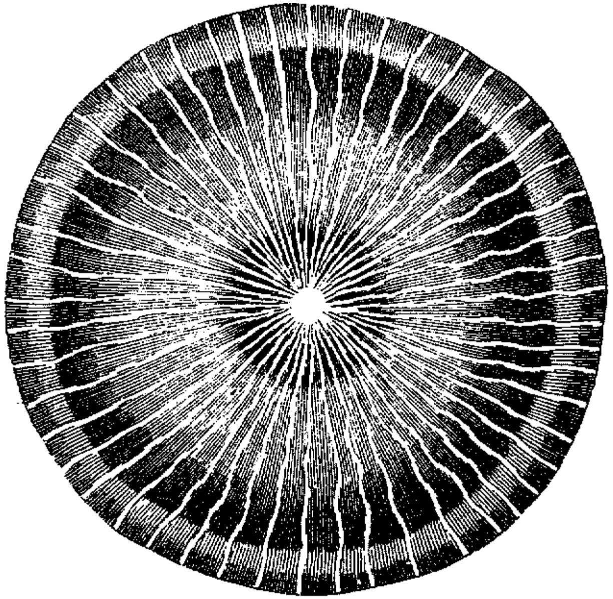


INTRODUCTION

For many of us, science seems to be the preserve of white-coated geniuses who patiently find the results of theories through painstaking tests and demonstrations. Everything is strictly controlled, processes and results duly observed and recorded, and conclusions are drawn. Everything is well organised, but it's all a bit ... regimented? Regulated? No – *responsible* is the word that seems to encapsulate this approach. And it doesn't seem like much fun.

How do we know that this is the way science operates? Because that's what we've seen in films and on the television screen – that's why. There's just no escaping that image. Or is there? What if, instead of being paragons of responsibility, scientists were actually *ir*responsible for a change?

There, again, a number of tried and true images spring from the screens and into our collective unconscious. Sure, we're heard about irresponsible – even mad – scientists. They're the ones who do things like creating Frankenstein's monster or who unwittingly change the course of an asteroid so that it starts heading for earth. Or maybe they unleash millions of giant ants after conducting atomic tests in the desert. All very interesting and entertaining, but just a little bit devastating.

HOME FIXTURES

Surely there is some way of getting involved in science that falls somewhere between these two extremes of buttoned-up responsibility and crazed end-of-the-world antics? Of course there is, and any decent red-blooded scientist would agree that it's possible to learn about the wider world 'without stabilisers', exploring

the ins and outs of science without footnotes and clipboards.

This is the world of *Wholly Irresponsible Science*, so put aside the Bunsen burner, flasks, test tubes and even the white coats. Instead, acquaint yourself with the scientific ingredients that you have around you at home. You may not realise it but your kitchen, bedroom and sitting room are scientific storerooms and labs rolled into one. Here is a world where lemons, eggs, bicarbonate of soda and balloons play more of a part than any more conventional 'scientific' paraphernalia. Why, there's even a chance to put that (unused) disposable nappy to use in the cause of science.

The 120 experiments described in the following pages use ingredients or materials that most households will already have, or that can be bought easily. And like the classic scientific experiments, which use questions as launch pads for enquiry, these experiments also seek to find and demonstrate answers.

Interspersed within the eight chapters are stirring accounts of famous exploits. Some were deliberately scientific; others we can observe with amusement as we distil them for their scientific essence. A lot of these fall into the 'don't try this at home' category, which definitely does not apply to any of the 120 experiments that are fully described in this book.

THE 'INNER CHILD'

Although billing itself as 'irresponsible', *Wholly Irresponsible Science* advocates due care and attention when conducting experiments. The presentation of each experiment is straightforward and logical, right down to any applicable words of special warning (in the Take Care! section). Instead it calls on readers to throw off some of the shackles of being a grown-up and find the child within us all.

No child, after all, would worry about flinging eggs at a clean bed sheet. And that inner child would hardly prefer sorting out an income tax return (or any other 'responsible' activity) to letting fly with a potato gun. If that means being irresponsible, m'Lud, then enter a plea of 'guilty'.

WHO CAN DO THESE EXPERIMENTS?

Any book that appeals to the 'child within us' is bound to appeal to children themselves, and this is no exception. We heartily recommend demonstrating each experiment to budding young scientists, and some of the experiments can involve children as volunteers or even participants. But bear in mind that the responsibility for each experiment lies with the adult conducting it. These experiments are *for* children as well as adults, but they are not to be conducted *by* them.

The final section of each experiment, Take care!, highlights any particular warnings relevant to the experiment. Some of these are no more than bits of friendly advice on how to get the best effects. Others have a more practical aim, of drawing the reader's attention to ingredients or actions that call for extra care. A Match alert signals an experiment that involves matches or an open flame.

HOW THIS BOOK WORKS

The 120 entries in *Wholly Irresponsible Science* are grouped into eight chapters, each representing a different scientific theme or intended result.

A typical entry introduces the nature of the experiment and what to expect, before breaking it down into the following sections.

YOU WILL NEED – A straightforward list of ingredients.

METHOD – Numbered step-by-step and easy-to-follow instructions.

THE SCIENTIFIC EXCUSE – The *raison d'être* for the experiment – or possibly your hurried explanation to an impatient or angry spouse!

TAKE CARE! – Special advice (and in some cases, warnings) for the experiment.

AT A GLANCE

The 120 experiments have also been grouped at the back on p. 297 according to how long it takes to complete them - from the first stage of preparation to the 'oohs' and 'aahs' at the conclusion. You might have a whole Saturday at your disposal or only a few minutes free.

The categories here will help you to choose an experiment that is perfect for the time you have available.

FLASH IN THE PAN – less than 2 minutes

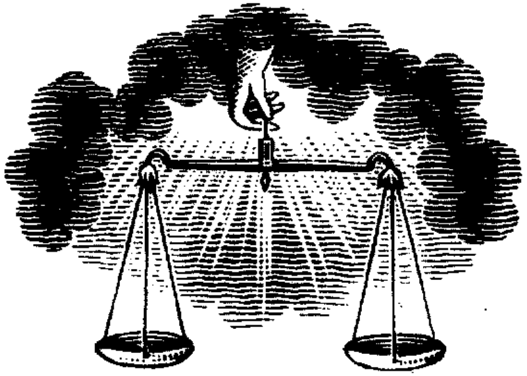
FIVE-MINUTE WONDERS – 2–5 minutes

ON THE HOUR – up to 1 hour

THE 8-HOUR DAY – 1–8 hours

GOING THE DISTANCE – a full day or more

For most of the experiments, a broad smile and an open mind will count for far more than a white coat and a calculator. So throw yourself into these funny, eye-opening, quirky experiments and see where they take you. And in the process you'll have a chance to learn – and maybe even teach others – a little science!

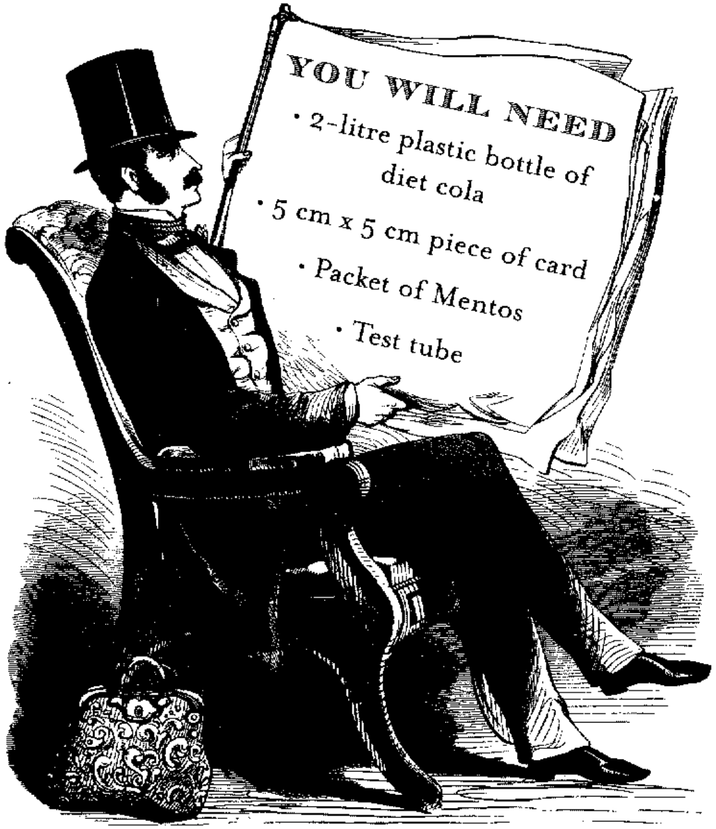


ELEMENTARY, MY DEAR WATSON

When Freddie Mercury sang 'thunderbolts and lightning, very very frightening' in 'Bohemian Rhapsody', he hit a raw nerve. Since the dawn of history, human beings have been fascinated and frightened in equal measure by the power of the elements. And while we have a better explanation for these phenomena than, say, the ancient Greeks, we still have a hard time linking them to everyday forces around us. The following experiments call on familiar ingredients – flour, water, pie plates, biros – to demonstrate how these phenomena work.

The Cola Geyser

Some of the most memorable experiments can be done using ingredients that don't seem in the least 'scientific'. For example, you can mix a popular sweet and an even more popular soft drink to create your own version of Old Faithful. The volatile mixture sends a geyser as high as 15m.



YOU WILL NEED

- 2-litre plastic bottle of diet cola
- 5 cm x 5 cm piece of card
- Packet of Mentos
- Test tube

METHOD

1. Put 12 Mentos in a test tube and hold the card to the open top of the tube.

2. Open the bottle of diet cola and put the test tube upside down on the top of the open bottle, still holding the card in place.

3. Take care to know which way to run.

4. Slide the card away quickly so that the Mentos drop in.

5. Run clear and watch as the cola explodes out of the bottle.

THE SCIENTIFIC EXCUSE

This explosive reaction comes from the sudden release of carbon dioxide, the gas that gives fizzy drinks their fizz. This carbon dioxide normally remains dissolved in the soft drink because there are no nucleation sites – irregularities around which bubbles can form. A single Mento, seen close up, has a craggy surface – providing hundreds of nucleation sites. A dozen of those sweets, dumped in at once, sets off a massive release of carbon dioxide, forcing the cola out of the bottle like a rocket. Diet cola works best because most non-diet colas use corn syrup, which suppresses the formation of bubbles.

TAKE CARE!

Do this experiment outside, well away from anything (or anyone) that you wouldn't want to become a sticky mess.

BACK-GARDEN VESUVIUS

This vivid display of a chemical reaction isn't dangerous, but it earns its place in this book by being very, very messy. It should go without saying that this is an outdoor experiment, so make sure you choose a dry day to demonstrate those dramatic lava flows. And if you're really feeling resourceful, you can add to-scale model houses at the base of the volcano. Make sure you don't clap when they get swept away.

• YOU WILL NEED •

- 75 cm x 75 cm plywood sheet (or larger)
- Empty 1-litre bottle (glass or plastic)
- Plasticine or papier-mâché (enough to form a 'volcanic cone' about 40 cm across at its base)
- 1 tbsp bicarbonate of soda
- 15 ml washing-up liquid
- Red or yellow food colouring
- 60 ml vinegar

METHOD

1. Put the empty bottle in the centre of the plywood sheet. It will be the centre of the volcano.
2. Build the volcano around this bottle, using either Plasticine or papier-mâché.
3. Work on and decorate the volcano while it's still soft, carving out gulleys and ravines for the lava flow.
4. Make sure the finished volcano has enough time to dry.
5. Add the bicarbonate of soda, the washing-up liquid and a squirt of food colouring to the empty bottle.
6. Measure out the vinegar and pour it into the bottle.
7. Stand back as the forces of nature take over!

THE SCIENTIFIC EXCUSE

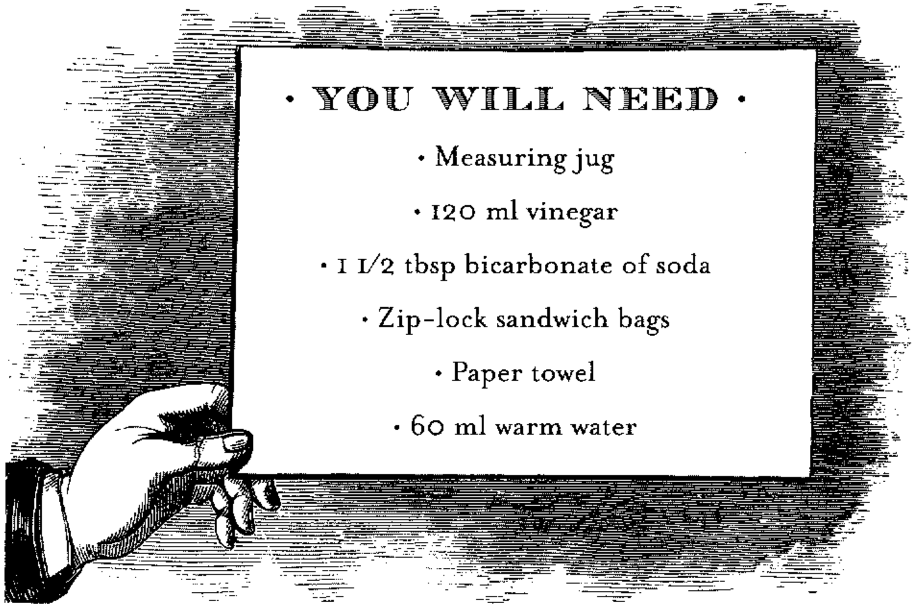
The trigger for the eruption is the addition of the vinegar (an acid) to the earlier mixture, which is basic thanks to the inclusion of bicarbonate of soda. Adding the vinegar triggers an 'acid/base neutralisation', as chemists would put it. More specifically, this reaction changes carbonic acid into water and carbon dioxide; the liberated carbon dioxide leads to the dramatic foaming.

TAKE CARE!

The biggest problem with this experiment is the possible mess, but giving too much of a warning here would be overdoing it, wouldn't it?

THE SANDWICH-BAG BOMB

Kids – and many grown-ups – may think of acids and bases as harmful chemicals that white-coated scientists keep locked away. This experiment is a simple way of showing that a kitchen cupboard has these chemical 'secret agents' in abundance. And with just a little outlay in time and equipment, you can get 'more bang for your buck', as the Americans say.



· YOU WILL NEED ·

- Measuring jug
- 120 ml vinegar
- 1 1/2 tbsp bicarbonate of soda
- Zip-lock sandwich bags
- Paper towel
- 60 ml warm water

METHOD

1. This experiment will work only if your sandwich bag has no holes. Test it by half-filling it with water, zipping it shut and turning it upside down over the sink.

2. If no water leaks out, you're fine. Empty the test water out.

3. Tear a sheet of paper towel into a square measuring about 15cm x 15cm.

4. Pour the bicarbonate of soda onto the centre of the paper towel, then fold the towel over itself with the powder inside it.

5. Pour into the bag the vinegar and warm water.

6. Then, carefully but quickly, add the paper-towel 'envelope' to the bag and seal it.

7. Shake the bag a little and then put it on the ground and stand back.

8. The bag will inflate and then pop with a satisfying bang.

THE SCIENTIFIC EXCUSE

The vinegar and bicarbonate of soda react dramatically and quickly, producing carbon dioxide equally quickly as a result. This carbon dioxide soon fills the bag and then, after straining at the bag's seams, pops it with a bang.

TAKE CARE!

No one is going to get hurt in this experiment but it can produce a mess. Choose your spot carefully beforehand, making sure nothing – or nobody – will get soaked or soiled!

FLAMEPROOF BALLOON

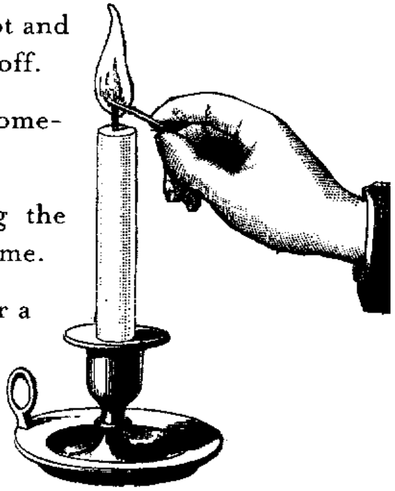
Here is another of those 'less is more' experiments. With precious little investment (how much does a balloon cost, after all?) and no real preparation, you can perform an experiment that is a real eye-opener. Balloons are always popping, aren't they? Yet why won't this one burst when it's placed in an open flame?

• YOU WILL NEED •

- Balloon (strong enough to hold water)
- Candle
- Matches
- Water
- 2-litre drink bottle full of water (optional)

METHOD

1. Fill the balloon with water until it is about the size of a grapefruit. You can do this by fitting the mouth of the balloon over a cold-water tap. Alternatively (if you're away from the kitchen), you can do the same thing over the mouth of the drink bottle.



2. Tie the balloon with a secure knot and shake it so that any excess drops fall off.

3. Light the candle and place it somewhere secure.

4. Hold the balloon by pinching the knotted end and move it into the flame.

5. Keep the balloon in the flame for a few seconds, then remove it.

6. Repeat the process – the balloon seems flameproof!

THE SCIENTIFIC EXCUSE

This experiment tells us a lot about heat absorption. If you held a 'normal' balloon (filled with air) in the flame it would burst quickly. The heat of the flame would weaken the rubber until it could no longer withstand the pressure of the air inside. Water, however, absorbs heat very well. This means that the water inside the balloon absorbs the heat of the flame, leaving the rubber more or less unscathed.

TAKE CARE!

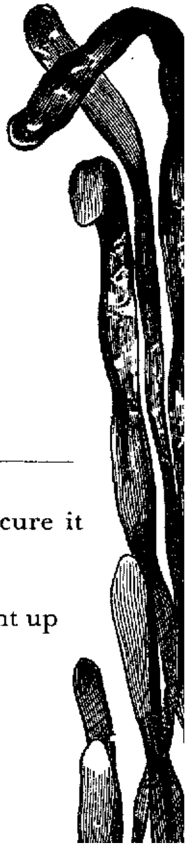
Blow out the candle after performing the experiment.

MATCH ALERT!

This experiment involves the use of matches and should be conducted only by a responsible adult.

BEACON FROM ATLANTIS

The advanced civilisation of Atlantis vanished beneath the waves before the time of the ancient Greeks. With it went – so the story goes – a wealth of knowledge, never to be recovered. But maybe not all of these skills have disappeared. How else could you explain a candle staying alight, even when it's under water? It must be a message from below.



· YOU WILL NEED ·

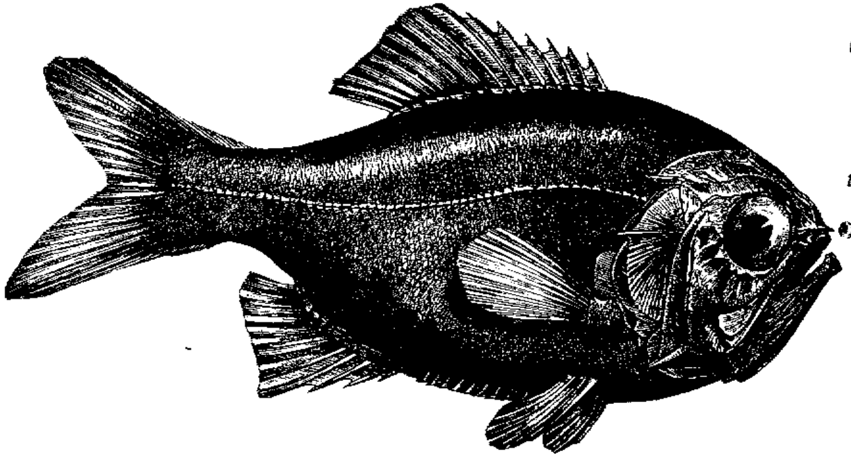
- Small mixing bowl (preferably clear)
- Candle (as tall as the bowl is high)
- Matches
- Water

METHOD

1. Heat the base of the candle and secure it inside the bowl in the centre.

2. Carefully fill the bowl with water right up to the rim of the candle.

3. Light the candle and observe.



4. The candle wick burns down, even below the water level, and forms a wax funnel around itself.

5. The flame, protected by the funnel, continues to burn for some time below water level.

THE SCIENTIFIC EXCUSE

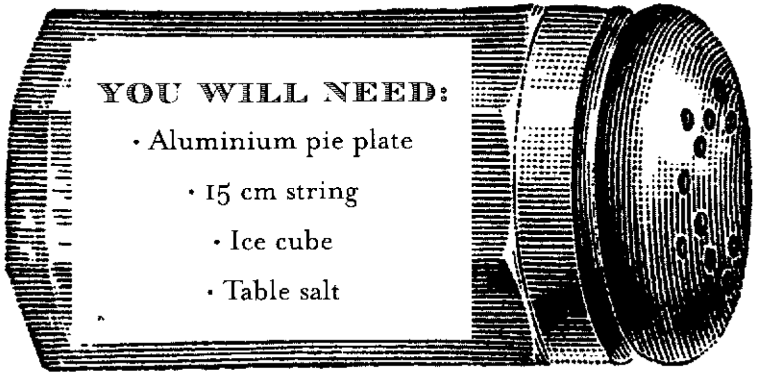
Normally, in the open air, the wax by the wick would melt and either evaporate or flow down the side of the candle. But water is excellent at absorbing heat, and it draws the warmth that would otherwise melt the wax. So instead of melting, the wax remains its solid funnel shape, guarding the flame like a dyke against the water outside.

MATCH ALERT!

This experiment involves the use of matches and should be conducted only by a responsible adult.

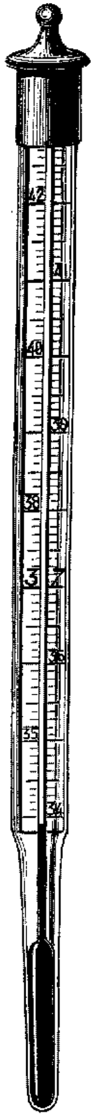
CAN YOU HOLD, PLEASE?

There's a little bit of magic in every scientific experiment, whether it concentrates on the tiniest particles or the speed of light through the infinity of space. This experiment inhabits that land of wonder and mystery, beginning as a puzzle and usually ending up with applause and laughter. Maybe it's best if you frame it as a challenge: can you pick this ice cube up from the pie plate without getting your fingers wet?



YOU WILL NEED:

- Aluminium pie plate
- 15 cm string
- Ice cube
- Table salt



METHOD

1. Rinse the ice cube and set it down on the foil pie plate.
2. Lay the string across the ice cube.
3. Sprinkle salt over the top of the ice cube, making sure much of it lands on or near the string.
4. Wait 15 seconds and then hold the two ends of the string.
5. Slowly lift the string, which will be holding the ice cube.

THE SCIENTIFIC EXCUSE

Salt lowers the freezing temperature of water (which is why roads are salted in winter). In this case, the salt causes some of the ice at the top of the cube to melt. The salty water is absorbed by the dry string, which lets the water at the top of the cube freeze over again. Except this time it has locked a length of string beneath the new layer of ice.

TAKE CARE!

Make sure you lift the two ends of string gently since a sudden jerk will almost certainly yank the string from the protective layer of ice.

HOME-MADE LIGHTNING

What's weather talk without a little exaggeration now and then? OK, well maybe real lightning is a few trillion times more powerful, but this experiment goes right to the heart of the science that produces a lightning bolt – an electrical discharge. In the case of real lightning, this discharge goes from cloud to cloud. Here the distance and scale are more modest – across the breadth of a fingernail. But with the lights out, and a good explanation, this can be a real crowd-pleaser.

YOU WILL NEED

- 30 cm x 10 cm x 3 cm polystyrene block
- Biro
- Glue
- Drawing pin
- Aluminium pie plate
- Woollen sock

METHOD

1. Push the drawing pin from the back of the foil pie plate through the centre.

2. Press the non-writing end of the pen onto the tack, securing with glue if needed.

3. Rub the polystyrene block quickly with the woollen sock.

4. Pick up the pie plate with the pen (not touching the pie plate itself).

5. Put the pie plate down carefully on the polystyrene.

6. Turn out the lights and draw your finger closer and closer to the pie plate.

7. You should see, hear and feel a small spark.

THE SCIENTIFIC EXCUSE

The rubbing causes (negatively charged) electrons to flow from the wool to the polystyrene, giving it a negative charge. Similar charges (positive and positive, or negative and negative) repel each other, so the electrons of the polystyrene cause some of the electrons in the pie plate to move away from the polystyrene. They are waiting to escape from the pie plate, but cannot move through the pen (because it is an insulator). They can, however, flow through the human body and jump across the small gap to reach the experimenter's finger.

TAKE CARE!

The following is not a safety warning (this is one of the safest experiments in the book). File it instead under 'follow this advice if you want the experiment to work'. Make sure you are holding the pen when you place the pie plate on the polystyrene. Otherwise, the excess electrons will flow undramatically from polystyrene to pie plate to finger.

HEAVY WEATHER?

Global warming, carbon emissions, the ozone layer – it can all seem a little rarefied, especially for young people with relatively little science background. But give them a chance to create some carbon dioxide – and then to see how it's a force to be reckoned with – and they might start taking carbon offsetting a little more seriously. Plus, there's always something spooky about invisible forces at work around us. Build yourself a home-made scale to prove that the invisible carbon dioxide is heavier than the equally invisible air.

YOU WILL NEED

- 2 clear plastic bags (sandwich-bag size)
- Sticky tape
- 30 cm ruler
- 3 tsp bicarbonate of soda
- Drawing pin
- 100 ml vinegar
- Drinking glass

METHOD

1. Secure the drawing pin (pointing up) to a surface, near the corner of a counter or table.

2. Tape the plastic bags (leaving a good upward-facing opening) to each end of the ruler.

3. Carefully balance the ruler on the drawing pin to create a set of home-made scales.

4. Mix the vinegar and bicarbonate of soda in the drinking glass.

5. When this mixture begins to froth, tilt the glass carefully over one of the open plastic bags. Do not pour any of the liquid or even the froth.

6. The bag beneath the tilted glass should slowly sink under the weight of the invisible new ingredient.

THE SCIENTIFIC EXCUSE

A diligent science student will recognise that mixing vinegar and bicarbonate of soda is one of the best – and easiest – ways of producing carbon dioxide. Carbon dioxide is a by-product of the reaction between the acid (vinegar) and base (bicarbonate of soda). Moreover, carbon dioxide is heavier than air. That's why it can be poured, just as one could pour a liquid, into one of the bags, causing the scale to tip.

TAKE CARE!

Tilt the glass gently, once you have mixed the vinegar and the bicarbonate of soda. Having gone through the bother of creating the delicate scale, you don't want to blow the experiment by pouring the liquid into the bag – the whole point is that the bag is dragged down by the invisible gas!

STATIC ELECTRICITY SLIME

This is one of the best experiments for younger scientists, with the messy and seemingly risky combination of ooze and electricity proving irresistible. See how many 'bright sparks' can work out what's happening. To give them a clue, try creating Home-made lightning (p. 40) first.

· YOU WILL NEED ·

20 cm x 20 cm x 3 cm polystyrene block
500 ml vegetable oil
Large drinking glass (a pint glass is ideal)
100 g cornflour
Woollen sock
Refrigerator

METHOD

1. Mix the oil and the cornflour in the glass.
2. Put this mixture in the refrigerator until it's well chilled.

3. Remove from the refrigerator and stir (don't worry if it has separated).
4. Let this mixture warm enough so that it can flow; it will resemble a slime at this point.
5. Rub the block of polystyrene on the woollen sock (or on your hair if there's no sock to hand).
6. Tip the container of slime and put the electrically charged polystyrene about 2 cm away from the slime. It should seem to stop flowing and even to gel.
7. Try wiggling the polystyrene: bits of the slime might break off and follow it.
8. You can refrigerate the slime in a sealed container after the experiment.

THE SCIENTIFIC EXCUSE

When rubbed, the polystyrene draws electrons from the wool (or hair), giving the polystyrene a negative charge. Meanwhile the oil and cornflour combine to make a substance known as a colloid. When the charged polystyrene nears the colloid, it causes the cornflour to line up, blocking the flow of the liquid oil. Taking the polystyrene away lets the mixture behave more like a normal liquid again.

TAKE CARE!

This is one of those rare experiments that's safe enough to recommend with few reservations. Just remember to make sure that your glass is big enough to hold the oil–cornflour mixture.

GIANT AIR CANNON

Simple ingredients, easy to make, dramatic results – some experiments queue up to be included in this book. This air cannon is a lot of fun to make, especially with young children. You can crank up the 'irresponsible' meter dramatically with flour or other non-hazardous powders to add to the effect.

• YOU WILL NEED •

- Strong plastic sheet
- Packaging tape
- Paper towels
- Flour
- 30 cm x 30 cm x 30 cm cardboard box

METHOD

1. Remove flaps from one end of the box. At the other end, tape together the flaps and cut out a single 15 cm circle.

2. Reinforce this circular opening with more tape.

3. Tape the plastic sheet over the open end, leaving plenty of slack; allow it to overlap each side by 12 cm before taping it securely.

4. Pinch the slack plastic sheet in the middle and then punch hard to operate the air cannon. You should get a satisfying whoosh of air.

5. Try putting some flour on the base of the cannon and then having a go. It should produce a blast of 'smoke'.

THE SCIENTIFIC EXCUSE

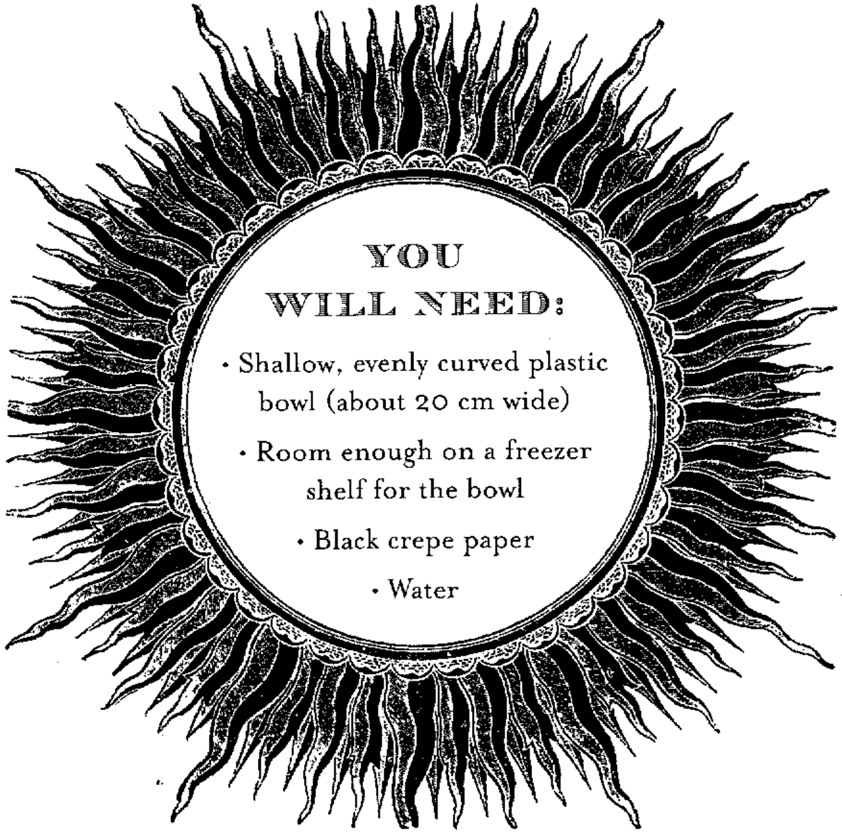
No matter how you doll up this experiment – with flour or with some other harmless powder – it's still easy to understand. With the plastic sheet kept slack, the cannon has a greater volume, and this naturally fills with air. The sudden punch reduces this volume quickly, causing the excess air to rush out.

TAKE CARE!

Not surprisingly, this is one of the least risky experiments in the book.

BURNING ICE

Lighting a fire with a block of ice? Surely that's a contradiction in terms! Try this experiment to see for yourself how the forces of nature can overturn common sense. It's certainly one display that you and your audience won't forget too easily.



YOU WILL NEED:

- Shallow, evenly curved plastic bowl (about 20 cm wide)
- Room enough on a freezer shelf for the bowl
- Black crepe paper
- Water

METHOD

1. Boil a saucepan of water for 3–4 minutes and let it cool to just above room temperature.
2. Fill the bowl with the previously boiled water.
3. Place the bowl of water on a shelf in the freezer and allow it to freeze completely.
4. Scrunch up a small piece of black crepe paper and set on a flameproof plate.
5. Remove the ice from the bowl (running a little warm water over the back of the bowl can help to release it).
6. Hold the ice, which is shaped like a lens, above the paper and direct the sunlight at the paper.
7. Keep the ice still until the paper begins to ignite.

THE SCIENTIFIC EXCUSE

This experiment operates under the same principle as letting a magnifying glass light an object: it concentrates, or refracts, the sunlight and focuses it on the paper. The ice has very little chance of cooling these rays. And boiling the water first is important as a way of 'purifying' the lens. Ordinary water has many bubbles inside it: even the tiniest ones (too small for us to see) can distort the lens and make it less effective.

TAKE CARE!

There are few risks tied in with this experiment. You needn't use a large piece of paper – the whole point is just to show how powerful the lens could be. Plus, there's no real fire risk if you let the paper catch fire, then make sure you put it out immediately.

THE KEY DATE FOR ELECTRICITY

What is it about wild weather that brings out the daredevil in some of the wisest people? Scores of ordinary nine-to-five types across America spend every spring poised to abandon their work cubicles at the drop of a hat. Then they jump into their cars to become 'storm chasers', tracking severe thunderstorms that they hope will develop into tornadoes.

More than 250 years ago, one of America's wisest statesmen risked electrocution in a similarly rash exercise – his aim was to unlock the secret of lightning. Benjamin Franklin did not have an established track record in death-defying stunts. He was more famous for his wise sayings (in *Poor Richard's Almanac*), the invention of bifocals and his diplomatic efforts in helping the United States become independent.

By the 1750s Franklin, like other scientists,

had become convinced that lightning was really the same as static electricity, but millions of times more powerful than the shocks that people get from woollen jumpers. He also knew that lightning strikes – or seeks out – high objects. The third thing that Franklin must have known – because he could not have survived his famous experiment in the face of a full-on electrical storm – was that the static electricity charge must build up as the storm brews.

With these things in mind, Franklin and his 21-year-old son William noticed dark clouds developing over Philadelphia one June afternoon in 1752. They launched a special kite that had a metal key at the end of its string. Extending from the suspended key were a ribbon (which Franklin held) and a wire leading down to a Leyden jar, which stores electrical charge.

Benjamin and William waited patiently as several clouds passed nearby: nothing happened to the kite or the key. Then Benjamin noticed that the strands of the string leading down from the kite had become wet, and possibly charged (an electrical charge would travel along a wet string far more easily). He held out his free hand to the key and as it drew near, there was a bright flash. It was instant proof that the kite had drawn some of the electrical charge downwards.

THE PAPER POLKA

Here's another one to file under 'why didn't I think of that?' We've all learned about positives and negatives, attraction and forces, but at times it feels a little bit too confined to the textbook. Is there any way to study this sort of thing that's a bit livelier, maybe lively enough to set your toes tapping? Well, maybe there is.

YOU WILL NEED

- Plastic box with clear, snap-shut lid (the ideal box would be shallow and the size of a shoebox)
- Paper confetti (or cut-up bits of paper from a shredder)
- Piece of cloth or wool

METHOD

1. Pour the confetti or cut-up paper into the box so that the bottom is not quite covered.
2. Snap the lid shut.
3. Rub the cloth or wool along the top of the lid.
4. The bits of paper will dance up and down inside the box.

THE SCIENTIFIC EXCUSE

This experiment is all about electrical charges and the properties of attraction and repulsion. Rubbing the surface of the lid imparts an electrical charge, which attracts the bits of paper. They rise up to meet the lid and then pick up the charge from it. In an instant it's a case of like pushing away like (the paper and lid having the same charge), so the paper is forced back. When they hit the bottom of the box, they lose that charge and are attracted back up to the lid.

TAKE CARE!

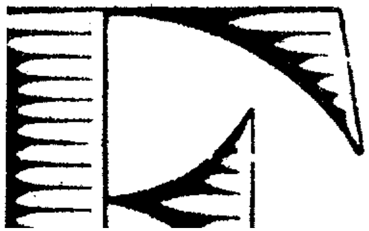
The modest scale of the electrical charge means that this experiment is harmless.

SPOOKY CALLING CARD

As Professor Liedenbrock and his anxious nephew Axel are beginning to feel lost among the endless underground tunnels in Jules Verne's *Journey to the Centre of the Earth*, their torch briefly illuminates two letters, 'AS', on the cavern wall. This sight brings them enormous relief, because they know they are indeed following in the footsteps of the great Danish explorer Arne Saknussemm. The image of the letters forming seemingly out of nowhere is startling, and enough to set any scientist wondering whether they too could pull off a clever trick with letters. Here's one way to do it.

YOU WILL NEED

- Plastic lid from a margarine or spreadable butter tub
- Card
- Sticky tape
- Scissors
- Pepper
- Pencil
- Some flannel



METHOD

1. Mark out a letter, about half the size of the margarine lid, on the card. This will become a stencil, so use a letter such as 'E', 'L' or 'V' rather than one that has a hole in it (such as 'O' or 'P').

2. Ensure that the curve or the lines forming this letter are 1 cm wide, and then cut out the shape.

3. Tape this stencil to the underside of the plastic lid.

4. Rub the stencil letter (i.e. the bits of plastic showing through the stencil) with the flannel for about ten seconds.

5. Taking care not to touch the bit you just rubbed, peel off the stencil and remove it.

6. Shake pepper over all the underside of the lid so that it forms a thin layer. Shake the lid to distribute it.

7. Flip the lid over so that the excess pepper falls off.

8. Flip the lid back to reveal the spooky letter.

THE SCIENTIFIC EXCUSE

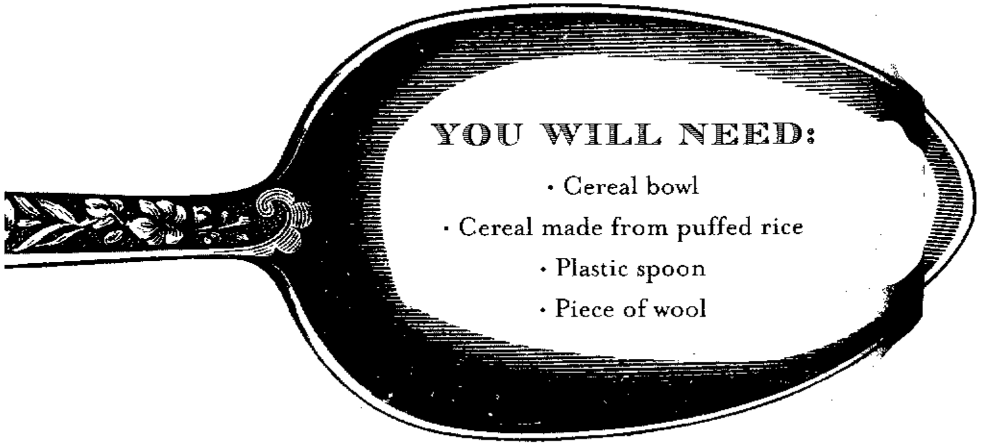
You've just harnessed the power of static electricity to hold the pepper on to the rubbed section of plastic lid. You obviously know why this happened, but will your fellow explorers?

TAKE CARE!

Make sure you give the flannel a good rub; it's virtually impossible to rub it too much, but not doing it enough will lessen the effect.

CRAZY CEREAL

Every science book needs at least one experiment that lets people go crazy over breakfast. And this one provides you with the least likely answer when your mother tells you to hurry up with your cereal: 'But Mum, the cereal just won't stay on my spoon!' You'd better be able to come up with a bit more than that, though, so read on until you feel happy enough with your excuse.



YOU WILL NEED:

- Cereal bowl
- Cereal made from puffed rice
- Plastic spoon
- Piece of wool

METHOD

1. Fill the bowl with the cereal as normal, but do not add milk.

2. Rub the spoon on the wool for about 15 seconds.

3. Hold the spoon over the bowl.

4. The bits of puffed rice will start to dance and bounce around, zinging off the spoon and all over the table.

THE SCIENTIFIC EXCUSE

Might this one really be called the oldest trick in the book? That's up to you. Of course, we're back in static electricity territory. Rubbing the spoon on the wool gave it a negative electrical charge. This charge, in turn, attracted the bits of puffed rice until they touched the spoon. That's when they transferred some of their electrons, and once their charge was the same as the spoon's, they dropped off.

TAKE CARE!

Make sure you clear up after yourself. Even smart-alec scientists know when to be polite.

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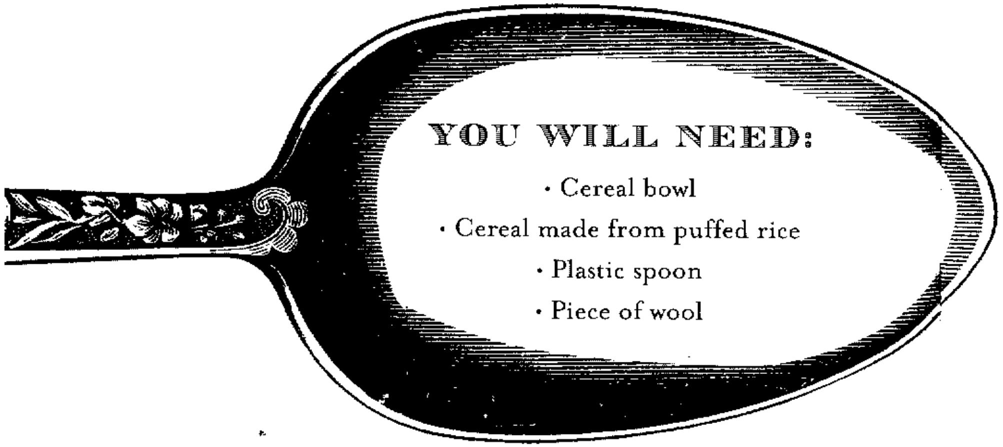

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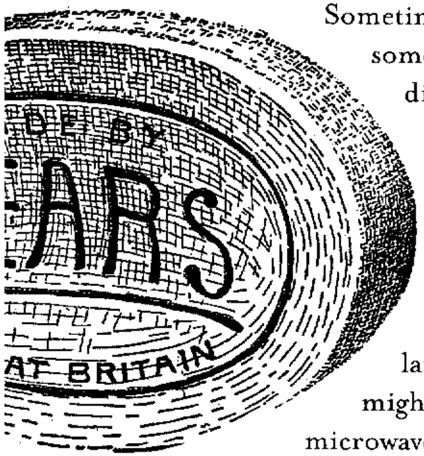
MICROWAVE SOAP



Sometimes you can learn a lot about something by looking at it from a different angle. This way-out experiment seems to be all about making merry with an 'explosive' bar of soap. There's no denying that the result of this demonstration will trigger 'oohs', 'aahs' and hoots of laughter. But along the way, you might finally get an idea of just how microwaves really work.

YOU WILL NEED

- Bar of soap
- Piece of paper towel
- Microwave oven

METHOD

1. Put the soap on the paper towel and put both in the centre of the microwave.

2. Cook the soap for two minutes on the highest setting.

3. Allow the soap to cool for one minute before touching it.

4. The cooled soap will be remarkably puffy but still rigid.

THE SCIENTIFIC EXCUSE

The key to this experiment is in the water, even though that wasn't one of the ingredients. All soap contains water, both in the chemical compound of the soap itself and also in the form of water vapour inside tiny air bubbles within the soap (the number of air bubbles can vary between soaps). The heat from the microwave causes the trapped water to vaporise and the trapped air to expand. Meanwhile, the soap has become much softer so that it puffs out because of all the expansion within it.

TAKE CARE!

The normal precautions about using a microwave apply to this experiment, which mean that it must be carried out by an adult. Be careful to let the 'cooked' soap cool before you touch it.

THE HURRICANE THAT WASN'T

The weather is one of the few topics where the British abandon their love of understatement. A few snowflakes blowing over some high ground become a 'blizzard'. A north wind immediately becomes 'polar'. Summer sun that would pass as early spring in Portugal or Peru becomes a 'scorcher'. Can you blame a leading Met Office forecaster for trying to calm viewers who might be expecting a hurricane?

That is exactly what Michael Fish tried to do in his evening forecast on 15 October 1987. Throughout the afternoon, a powerful storm was developing in the Bay of Biscay along the Atlantic coast of France. And it was moving north towards the southern half of Great Britain.

Things get a bit peculiar at this point. It's likely that 99 per cent of viewers who saw the BBC TV forecast that night will remember this comment from Mr Fish:

> Earlier on today apparently a lady rang the BBC and said she heard that there was a hurricane on the way. Well don't worry if you're watching, there isn't.

They will also remember the storm that ripped across the country that night after most people had gone to bed, with gusts reaching nearly 200 km/h. Sixteen people died because of storm damage. Buildings broke, collapsed or were very nearly blown away. Ships ran aground along the Channel coast, where flooding also became a problem. An estimated 15 million trees were uprooted in the storm. Weather experts considered it to be the worst storm in southern Britain since 1703.

Poor Michael Fish immediately found himself linked to the most misguided bit of reassurance since Icarus boasted about his wings. But did he have a point?

He could use two lines of defence. First, strictly speaking, the storm of 1987 was not a hurricane, since it did not originate in the tropics and did not have sustained wind speeds of 125 km/h. Second, he did actually advise viewers to 'batten down the hatches because there's some really stormy weather on the way'. The 'don't worry' quote actually referred to a news item earlier in the bulletin about a hurricane near Florida. That hurricane, of course, never reached Britain. But the damage had already been done.

CREATE A COLD FRONT

We all know what it's like to listen out for a weather forecast and then be disappointed when it turns out wrong and our plans go down the drain. Wouldn't it be lovely to be able to predict when it will turn cloudy – and even when it will begin to rain – right down to the last second? Actually, it might be easier than you think to pull off that trick.

YOU WILL NEED

- Wide-mouthed glass jar
- Hot water
- High-rimmed metal baking tray
- Tray of ice cubes
- Torch

METHOD

1. Place the jar on a counter and fill it to a depth of about 3 cm with hot water.

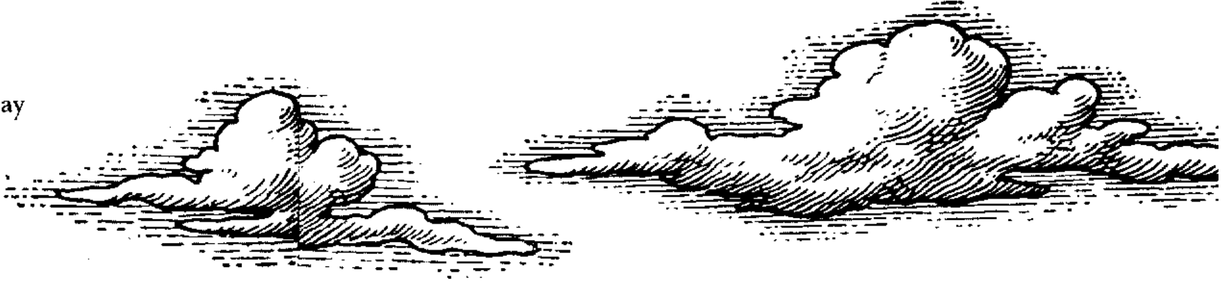
2. Empty the ice cubes into the baking tray and set the tray on top of the jar.

3. Turn off the main room light.

4. Shine the torch into the jar to reveal a foggy cloud forming inside.

THE SCIENTIFIC EXCUSE

You've created a mini weather system in this experiment. The hot water at the base of the jar warms the air, which then rises. This air has also absorbed some of the water in the form of tiny droplets. At the top, though, it hits the cold base of the baking tray. The humid air cools rapidly, forming a cloud – just as your warm, humid breath does when you breathe out on a cold day. Look a bit closer and you'll see that some drops of water are forming on the bottom of the tray and are about to drop off. That is just what happens when raindrops form.



TAKE CARE!

Make sure you use hot, but not boiling, water in this experiment. Boiling water could cause the glass to crack, which could in turn lead to cuts and scalds.

STORM IN A … BOTTLE

One of the scariest sights on Earth is that of a tornado approaching across level farmland, sucking up and spitting out everything in its path. How would you like to send some shivers down the spines of your family and friends – in fact, anyone who might stumble upon your secret lab? Even if no one's house is likely to be swept away as in *The Wizard of Oz*, you'll have given a hint that your next version could be a little more powerful.

YOU WILL NEED

- Empty 2-litre drinks bottle
- Water
- Sink or basin
- 1 tbsp olive oil

METHOD

1. Fill the bottle almost to the top with water.

2. Add the olive oil.

3. Keep one hand on the opening of the bottle and carefully turn it upside down over the sink or basin.

4. Begin swirling the bottle steadily in a clockwise direction.

5. Take your hand away from the opening but continue to swirl; try to hold the bottle with one hand at the base of the bottle (which is now at the top), and the other close to the mouth but not blocking your view of the water moving inside.

6. The water should be swirling inside, with the darker oil heading down first through the 'twister'.

THE SCIENTIFIC EXCUSE

The swirling water inside the bottle is called a vortex, and massive versions of these can form in some severe thunderstorms to create tornadoes. The centre of the vortex is hollow, which allows air to rush up. That air rushing up allows the bottle to empty faster: just think how long it would take to empty the bottle without swirling it. The olive oil is less dense than the water, so it rests on the surface and is the first to be sent spiralling from the vortex.

TAKE CARE!

It's obviously safer to use a plastic bottle than a glass one, but if you are very careful you'll find that a glass bottle is actually better. It's very hard to avoid squeezing a plastic bottle, and that can lessen the tornado effect.

ALWAYS TAKE THE WEATHER

The New Zealand group Crowded House had an international hit in the 1990s singing about taking the weather with them – or was it with you? Could they have been chronicling their scientific efforts through popular music? Even if their song's title is a mere coincidence, you'll have a chance to do some portable weather creation once you've mastered this experiment.

YOU WILL NEED

- One rubber glove
- A wide-rimmed, 3-litre screw-top jar
- Matches
- Water

METHOD

1. Add just enough water to cover the bottom of the jar.

2. Drop a lit match into the jar.

3. Put the glove on, and fit it over the rim of the jar so that the fingers point downward. Keep wearing the glove even after it is sealed around the rim.

4. Pull the glove upwards, but not quite out of the jar: make sure it is still attached around the rim.

5. A foggy cloud will develop instantly.

6. Put the glove back into the jar and watch the cloud disappear.

THE SCIENTIFIC EXCUSE

The air inside the jar contains water in the form of water vapour, a gas. When you pull out the glove, the air expands; this expansion also causes the air to cool. And when the air cools, some of the water vapour condenses to create visible particles in the form of the cloud. Pushing the glove back does the opposite, reheating the air and causing the cloud to turn back to invisible vapour.

Why the match? Droplets form more easily around small solids suspended in the air, like the tiny particles of smoke from the match. Farmers who are desperate for rain will sometimes try to 'seed' clouds by spraying small particles of dry ice from planes.

TAKE CARE!

There's no risk involved with this experiment, but take care that you maintain the seal of the glove against the rim to make sure it works according to plan.

MATCH ALERT!

This experiment involves the use of matches and should only be conducted by a responsible adult.

WATER GREAT IDEA

Water, water everywhere,
And all the boards did shrink;
Water, water everywhere,
Nor any drop to drink.

Could the great poet Samuel Taylor Coleridge have been writing about the following chapter, which uses water as the source of scientific magic? Maybe not, but think of how useful he'd have found a DIY ocean – and a mum to row across it with him.

DAN'S ROW WITH HIS MUM

The idea of crossing the Atlantic – especially from east to west – has captured people's imaginations for centuries. Debate rages about who 'discovered America'. Was it Columbus in 1492? Leif Erikson and his Viking voyagers 500 years earlier? Or maybe Saint Brendan from Ireland and his band of monks, sailing in small ox-hide vessels in the sixth century?

Just as tantalising are the stories of Atlantic crossings after Columbus – the fastest, the first single-handed, the youngest single-handed, the first in a rowing boat. Most of these chronicle solitary exploits, or shared efforts by tough sailors. None of them mentions a mariner rowing across the Atlantic with *his mother*.

That is exactly what Dan Byles did in 1997. Byles, 23 years old at the time, had learned of the first Atlantic Rowing Race, founded by British sailing hero Chay Blyth, in 1995. At the time, more

people had climbed Everest and been in space than had rowed across the Atlantic: six had died trying. Byles and a friend began training, but work commitments soon ended the friend's involvement.

Dan did what young men often do in times of need – he turned to his mother for help. Jan Meeks, 50 and recently widowed, was looking for ways to keep her spirits up. Her son's offer was unexpected – especially as Jan preferred quiet evenings in, listening to classical music. Her only rowing experience had been on the Serpentine when she was eight. But she agreed, and the pair spent 18 months training for the crossing. Jan had to remortgage her house to build the 6.5-metre wooden boat.

The race was as challenging as they had expected. Equipped with a £30 camping stove, no satellite phone and only one set of foul-weather gear between them, they set off on the 4,900-km voyage from Tenerife to Barbados. They encountered whales, sharks and waves as large as a house. Jan joked that the boils she developed made her bottom look like a pizza.

After 101 days at sea, they crossed the finishing line. They came 22nd out of the 22 teams to complete the race, but they had set two records: as the first mother-and-son team to row across the Atlantic, and as the oldest person to row across the Atlantic.

BACK-UP PLAN

'Darling, the toilet is backed up.' There's a phrase designed to strike terror into the heart of the average newspaper-reading husband. Somehow, 'darling, the glass has backed up' lacks a bit of edge. But what it lacks in shock, it makes up for in wonder. Here is an experiment that deserves an audience: even Dad might come willingly when he learns he's only a bystander.

YOU WILL NEED

- Shallow baking tray or aluminium pie plate
- Candle
- Matches or lighter
- Water
- Drinking glass or flask (about 350 ml capacity)

METHOD

1. Light the candle and drip some wax onto the centre of the baking tray or pie plate.
2. Anchor the still-burning candle in the wax before it hardens.

3. Fill the tray or plate about halfway up with water.
4. Place the glass or flask upside down over the candle.
5. After a few seconds, the candle will burn out, then water will rise up into the upturned glass and remain at a higher level than in the surrounding pan.

THE SCIENTIFIC EXCUSE

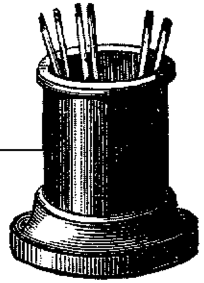
Air pressure – or more precisely, different air pressures – do the work of this experiment. By placing the cup over the burning flame, you help the air inside warm up. But it is a limited supply of air, and the candle soon burns up all the oxygen from the air ... and in short order the air begins to cool. That is where the pressure comes in: cooler air exerts less pressure than the previously-warmed air. The water rushes in because there is less air pressure to hold it back.

TAKE CARE!

Make sure you drip enough wax to support the candle securely, since a sudden bump could cause an unstable candle to wobble and tip over. Try adding a drop or two of food colouring to the water in case people need to see the experiment from a little distance.

MATCH ALERT!

This experiment involves the use of matches and should only be conducted by a responsible adult.



THE MAGIC CIRCLE

If only every household object acted as obediently as the little piece of string in this experiment. Life would be so much easier if we could wave a cotton bud at some batter and it immediately became a cake, or if we could touch a sheet and the bed made itself. These breakthroughs will come in good time, no doubt. In the meantime, try to make do with this little bit of magic.

YOU WILL NEED

- Shallow baking dish
- 20 cm-long piece of string
- Water
- Cotton bud
- Washing-up liquid

METHOD

1. Fill the baking dish about halfway up with water.
2. Tie the ends of the string to make a circle.
3. Float the string on the water; it will lose its circular shape.
4. Dip a cotton bud in some washing-up liquid and then dip this soapy end inside the floating string.
5. The string will quickly become a perfect circle.

THE SCIENTIFIC EXCUSE

We often read about something 'breaking the tension', and in this case it is the washing-up liquid that does just that. The molecules along the top of the water are held together – making a sort of 'skin' – by surface tension. The soap, however, is able to pierce between the water molecules and break this skin. The newly freed liquid particles move out from the soap. Because they exert a similar force along the entire inside of the string, they force it into an exact circle.

TAKE CARE!

There's no real need to worry with this experiment. Just make sure no one mistakes the soapy solution for water when you've finished.

CORK ON A BENDER

You might be feeling a little the worse for wear yourself, if you overplay your hand with this display and come across as too much of a wizard. At its heart, of course, is a sound scientific principle, but without test tubes and Bunsen burners to act as props, your audience might think some other force is at work here. Bear in mind that this is one of the simplest and quickest experiments you can possibly perform, so enjoy it.

· YOU WILL NEED ·

- Drinking glass
- Wine cork
- Water
- A willing volunteer

METHOD

1. Fill the glass almost to the top with water.

2. Ask a volunteer to place the cork so that it floats in the centre of the water. (It won't, and will keep drifting to the side.)

3. Explain that you will succeed where they have failed; take the cork out and fill the glass right to the top with water.

4. Now, you take your turn and show how the cork can remain exactly in the centre as you had planned.

THE SCIENTIFIC EXCUSE

When the glass was partially filled, the water clung slightly to the inside of the glass, causing a slight lip to form around the edge of the water. The cork, being buoyant, simply floated to the highest point – the edge. The 'full' glass, on the other hand, is slightly fuller than full because water tension causes the surface to bulge. Now the highest point is in the centre, at the top of the bulge. And that is where the cork will remain.

TAKE CARE!

The biggest risk you'll face is from your frustrated volunteer, who might want to exact some sort of revenge. Watch your back!

-THE- NO-FLOW SIEVE

Everyone has a good idea of how a sieve works, whether it's used for panning for gold or preparing pasta. It's simple: water or some other liquid flows through freely, leaving solids (which don't fit through the gaps) behind. But what about a sieve that won't let any water through, even when you know there are some gaps in there? Is there a gap in your knowledge, or is there something more to it?

· YOU WILL NEED ·

- 20 cm x 20 cm piece of wire gauze (as used for mosquito-proofing)
- 1-litre glass bottle or jar (ideally with mouth about 6–8 cm wide)
- Strong elastic band
- Water
- A friendly volunteer

METHOD

1. Hold the piece of wire gauze up and blow through it (to silence doubters later).
2. Fill the bottle right to the top with water.
3. Fit the gauze over the mouth of the bottle and secure it with the elastic band.
4. Ask your friend to put his hand over the top of the bottle and to turn it upside down, still holding his hand over the mouth.
5. Now ask your friend to position the bottle, still upside down, over your head and then to pull his hand away quickly.
6. No water will have poured out of the bottle, and your head should stay dry.

THE SCIENTIFIC EXCUSE

Surface tension, the force that holds molecules together, helps water form a 'skin' when it comes into contact with air. This skin anchors itself on solid objects such as the side of a glass, or in this case the tiny metal cross-bars that make up the gauze. Hundreds of these tiny water barriers (held firm with surface tension) keep the water from flowing out when the bottle is turned upside down.

TAKE CARE!

The directions above lead to a low-risk result – even if the experiment failed, the only person to suffer would be you. On the other hand, the same display becomes really irresponsible if you try it on someone else – a grumpy uncle, perhaps?

SILENT ERUPTION

Every now and then, you will come across an experiment that will have you shaking your head and wondering, 'Did I really make that happen?' Usually this kind of head-scratching demonstration is the sort that comes with very little equipment and even less in the way of scientific props. Sit back now, and watch this pair of very ordinary bottles – with even more ordinary ingredients – perform an extraordinary feat.

YOU WILL NEED:

- 2 identical 1-litre glass bottles (each with mouth about 6–8 cm wide)
- Piece of card about 10 cm square
- Hot water
- Cold water
- Ink

METHOD

1. Fill one bottle with cold water and the other with hot water (both from the tap).

2. Add some ink to the bottle of hot water and swish the bottle round so that the colour is uniform.

3. Make sure that each bottle is completely full; top up if necessary.

4. Press the piece of card to the top of the cold-water bottle.

5. Keeping the card firmly in place, turn the 'cold' bottle upside down so that it rests exactly above the top of the 'hot' bottle. (The card is lodged between them.)

6. Holding the bottles firmly, slide the card out from between them.

7. The ink-coloured hot water will rise into the top bottle and clear cold water will flow down into the other bottle.

THE SCIENTIFIC EXCUSE

The key to this experiment is buoyancy, the upward force that keeps ships – and swimmers – afloat. Warm water rises within a closed system just as warm air rises outside. In this case, the warmer water is easy to identify because of the ink, but the clear, cooler water is just as recognisable as it eases past the inky water to rest at the bottom of the lower bottle.

TAKE CARE!

Mastering the 'bottle-flip' can take time. It's worth having a few test runs, first with empty bottles and then with cold water in both, until you feel you can do it easily.

-THE- FLOATING NEEDLE

Here's a quick test. Put a piece of tissue and a sewing needle in a glass and one of them will float. But which one? Try this experiment to get a real eye-opener about water power. You might want to make a friendly bet with your audience as well!

YOU WILL NEED

- Drinking glass
- Piece of tissue
- Small sewing needle
- Water

METHOD

1. Fill the glass right to the brim with water.

2. Tear a square of tissue just smaller than the size of the glass.

3. Carefully lay the needle on the tissue and lower them both down to the surface of the water.

4. The tissue will float, with the needle on it, before sinking down ...

5. ... but the needle will remain floating on the surface of the water.

THE SCIENTIFIC EXCUSE

Here's another demonstration of surface tension, and maybe one that will stick in people's memories because it seems so wrong – until they think it through. Most of a tissue is actually air, and once the air is driven out of the tissue (as it gets soaked) most of what is left is water. The sodden tissue sinks to the bottom of the glass but the water molecules by then have regrouped, re-establishing surface tension which keeps the needle floating.

TAKE CARE!

Be careful handling the needle and make sure it is put away when the experiment is finished.

GHOSTLY SKATER

For thousands of years, scientists and philosophers have tried to find the secret of perpetual motion. That mysterious goal has remained elusive, despite mankind's progress in science and technology. But maybe they've all been looking in the wrong places – in distant galaxies or in the nano-worlds of electron microscopes. What if the secret were closer to hand ... maybe on the kitchen counter?

YOU WILL NEED

- 1 cm-thick slab of cork (about 12 cm square)
- 4 double-ended needles (about 6 cm long)
- 3–4 camphor mothballs
- 30 cm-wide bowl
- Card or construction paper
- Coloured pencils
- Knife
- Water
- Rubber gloves

METHOD

1. Draw a figure of a twirling skater on the card; cut out and colour in this shape, leaving a small tab extending from the bottom.
2. Cut a 5–6 cm-wide circle and four 2 cm squares from the cork.
3. Make a small slit in the centre of the cork circle and slip the tab (from the base of the skater) into it. The skater should be upright.
4. Cut 5 mm-wide V-shapes from one side of each of the cork squares. Put on the rubber gloves for the remaining steps.
5. Cut a small piece of mothball to fit in each of the V-shapes.
6. Fit a needle into each cork square, on the opposite side to the mothball.
7. Fit the other end of each needle into the edge of the cork circle, so that they form a cross shape with the cork in the centre.
8. Fill the bowl almost to the top and place the 'cork cross' on it.
9. The skater will twirl and twirl.

THE SCIENTIFIC EXCUSE

This experiment is a bit of a change from some of the others in this chapter because it works by *reducing* the surface tension of the water. The camphor in the pieces of mothball slowly dissolve and create a camphor solution as they mix with the water. This camphor solution has less surface tension than normal water. So, the 'pull' of the water on the leading side of each cork rectangle is stronger than the pull from the mothball side. Put simply, the stronger pull wins and the corks go round and round ... as does the spooky skater above.

TAKE CARE!

Wearing rubber gloves protects your hands from the camphor, which can irritate the skin. Take great care in cutting out all the shapes; if a sharp knife is used for this cutting, make sure an adult does it.

THE DIY OCEAN

Pity the poor children who spend their childhood well away from the sea, never hearing the rhythmic lap of waves against the shore. This quick and easy experiment gives them a glimpse of the seashore, minus the sunburn and sand flies. As for rhythmic lapping, you might still have to rely on the family dog.

• YOU WILL NEED •

- Empty 2-litre plastic bottle (with cap)
- Funnel
- Blue food colouring
- Water
- Cooking oil (sunflower oil works well)

METHOD

1. Fill the bottle about a third of the way up with water.

2. Add several drops of food colouring and swirl the bottle a few times to mix it in.

3. Use the funnel to fill the rest of the bottle with cooking oil.

4. Cap the bottle tightly.

5. Hold the bottle horizontally, raising and lowering one end.

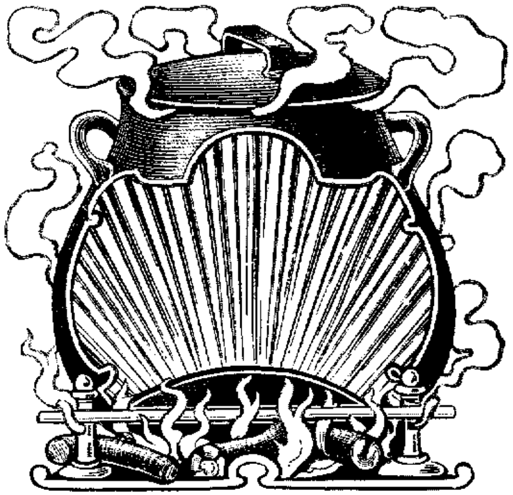
6. The dyed water will seem to make blue waves as it rocks back and forth.

THE SCIENTIFIC EXCUSE

This mesmerising display of wave power is a wonderful demonstration of how oil and water do not mix. Bear in mind two important points. First, a denser liquid (in this case water) will sink below a lighter one. But that doesn't explain why the two liquids don't just mix together to form a new one, like white coffee. That is because the oil is not strong enough to break the powerful hydrogen bonds that hold the water molecules together. The two liquids are destined to remain forever separate.

TAKE CARE!

Make sure the cap remains tightly sealed throughout this experiment, as otherwise the clean-up could be lengthy.



FOOD FOR THOUGHT

It's amazing to think that just about every branch of science can be studied in the kitchen, using ingredients from the store cupboard, refrigerator, larder or cutlery drawer. Billowing black smoke, flying potato pieces, a mysterious growing hand – these things are the real stuff of science, aren't they? You can eat some of the results, but you might find that others have simply disappeared. All of this gives a wild new twist to the term 'domestic science'.

BACON SMOKESCREEN

Here's a way to indulge your wish to enter the world of smoke and mirrors. Smokescreens are popular with young and old, and the modicum of science that underpins this effort can help keep your conscience clean. It's a straightforward, hard-to-miss exercise that has the benefit of providing lunch (if you cook the lean bacon at the same time).

· YOU WILL NEED ·

- Packet of streaky bacon rashers (thin American-style works well)
- Frying pan
- 20 cm x 15 cm aluminium foil
- String
- Matches

METHOD

1. Cut the fat off the rashers and fry it until it becomes liquid.
2. As the fat is frying, form a tube from the aluminium foil, sealing one end of the tube and keeping the other open.
3. When the fat has completely melted, pour it into the tube.

4. Cut a length of string 2–3 cm longer than the height of the tube.
5. When the fat has begun to set, but is still malleable, feed the string into it so that the extra 2–3 cm protrudes (it will serve as a wick).
6. When the fat has hardened, take it from the tube and place on a non-flammable base (possibly also made from foil).
7. Light the fuse; it will burn like a candle but will emit a thick black smoke.

THE SCIENTIFIC EXCUSE

A car, without the right fuel mix (petrol and oxygen), will not 'flash burn' efficiently and will burn off the petrol with far more smoke. This experiment presents a mini-version of the same thing – a mix that scores high on fuel (the fat) and low on oxygen, providing the slow-burning part of things. The inherent impurities in animal fat (particles of meat and bone that burn black) mean that the smoke becomes very dark.

TAKE CARE!

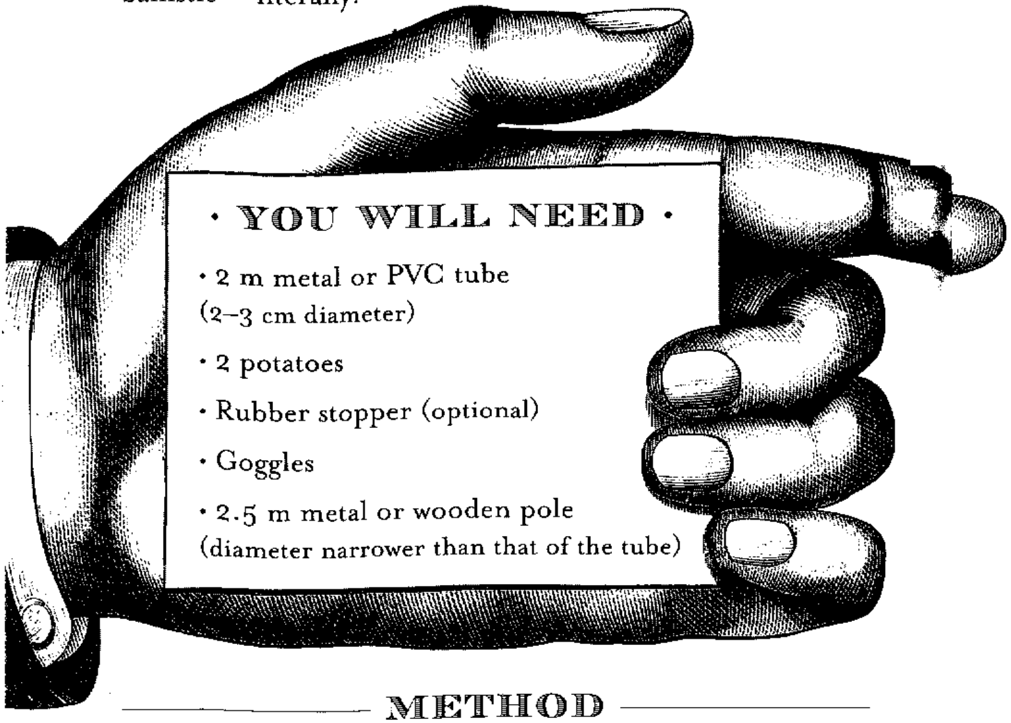
Although the smokescreen isn't dangerous, it does produce a great deal of smoke. Now that, of course, is the whole point of the experiment but do plan ahead, taking into account ventilation, wind speed, who's likely to see or smell the smoke, etc.

MATCH ALERT!

This experiment involves the use of matches and should be conducted only by a responsible adult.

POTATO GUN

This experiment takes the notion of a food fight and introduces a note of the 'arms race'. The basic ammunition is simple enough – the humble potato. But with a little preparation, and some help from Boyle's Law, the potato will 'go ballistic' – literally!



• YOU WILL NEED •

- 2 m metal or PVC tube (2–3 cm diameter)
- 2 potatoes
- Rubber stopper (optional)
- Goggles
- 2.5 m metal or wooden pole (diameter narrower than that of the tube)

METHOD

1. Press one end of the metal tube down onto a potato, so that a plug of potato becomes lodged at the end.

2. Repeat this process with the other end of the tube on another potato so that you have a potato plug at each end.

3. Hold the tube with one hand with one end pointing away from you – and away from anything breakable.

4. Position the pole at the closer end of the tube, just touching the potato plug. (If the pole is much narrower than the tube, add a rubber stopper to the end touching the potato.)

5. Put on your goggles and ram the pole quickly down the tube, pushing one potato plug towards the other.

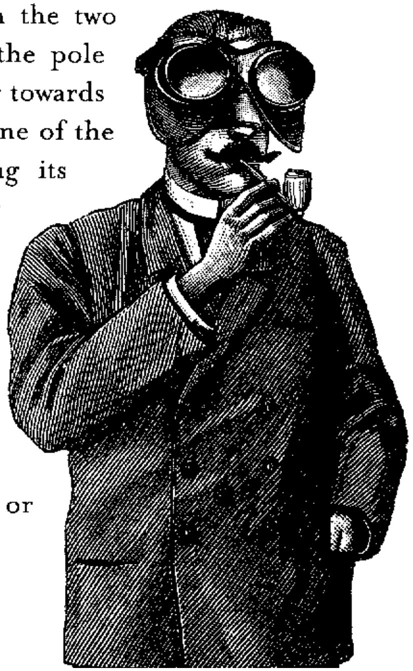
6. The plug at the far ('barrel') end will shoot out at great force!

— THE SCIENTIFIC EXCUSE —

This experiment is an explosive demonstration of Boyle's Law – pressure increases as volume decreases. Scientifically stated, this means that: 'Under constant temperature, the volume of a gas is inversely proportional to the total amount of pressure applied.' In this experiment, the gas is the air inside the tube, lodged between the two potato plugs. When you shove the pole into the tube, you push one plug towards the other. This reduces the volume of the gas suddenly, thereby increasing its pressure suddenly. Something has to give: the burst of pressure sends the potato plug flying.

— TAKE CARE! —

Don't point the potato gun in the direction of anyone watching – or towards any breakable china or crockery!



FRANKENSTEIN'S HAND

Here's a 'hands-on' demonstration of a scientific principle that has cropped up elsewhere in this book: the chemical reaction between a common acid and an equally familiar base. You can give this experiment something of a Halloween flavour by marking the glove with bones, veins and screws. Young children will love the special effects as the hand grows and grows.

· YOU WILL NEED ·

- Rubber glove
- 2 tsp bicarbonate of soda
- 50 ml vinegar
- 250-ml beaker

METHOD

1. Pour the vinegar into the beaker.

2. Add the bicarbonate of soda to the inside of the glove. Hold the glove by its wrist and shake the powder into the fingers.

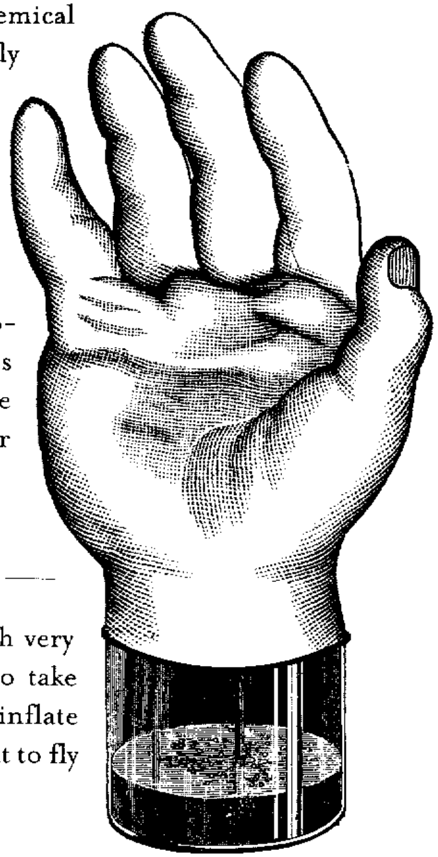
3. Carefully attach the glove to the top of the beaker so there's no gap.

4. Pull the glove upright by its fingertips and shake gently, allowing the bicarbonate of soda to drop into the beaker.

5. Stand back and watch as Frankenstein's hand begins to inflate.

— THE SCIENTIFIC EXCUSE —

Bicarbonate of soda is a chemical base, which reacts strongly with the acetic acid of the vinegar. One of the by-products of this reaction is carbon dioxide, which increases the pressure inside the glove–beaker arrangement. As more gas is produced, this pressure increases further and pushes out the weaker surface (the rubber glove), inflating it gently.



— TAKE CARE! —

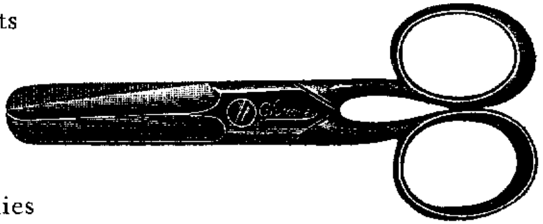
This is a safe experiment with very little risk. You might want to take care that the glove doesn't inflate too much, which could cause it to fly off the beaker.

EGG BUNGEE JUMP

Have you ever done a bungee jump? Does it give you the shakes just thinking about it? How about trying a home version of it, but with an added, possibly very messy ingredient that might leave you quite literally with egg on your face.

YOU WILL NEED

- 6 eggs (although one should be enough)
- Pair of old tights
- Strong tape
- Scissors
- Ruler
- Supply of pennies
- Ladder (if no tree branch is available)
- Old newspaper



METHOD

1. Choose a spot for the bungee jump: ideally a tree branch outside but it could also work from a ladder. You want the egg to fall to within 3 cm of the ground but no closer; use the ruler to measure this distance.

2. Work out the weight of the egg beforehand to do a test run: hold the egg in one hand and keep adding pennies to the other until you feel the pile weighs the same as the egg.

3. Add the 'egg's worth' of pennies to a leg of the tights and tape the other end to branch or ladder.

4. Do a test run – let the coins fall and check their distance from the ground. Make any necessary adjustments to where you have tied the tights to the ladder or branch.

5. Now try the jump with the egg instead of the coins.

THE SCIENTIFIC EXCUSE

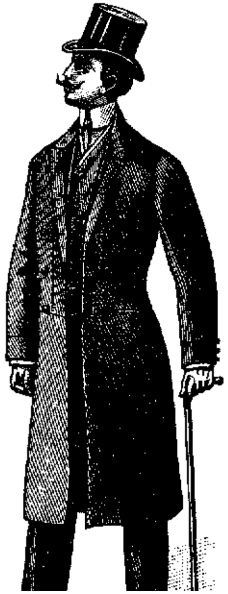
The nylon or other fabric of the tights has a natural elasticity – a certain force will take it so far before the strength of the fabric pulls it back. The measuring and the test runs might all seem like good fun, but you – or your assistants – are actually working out the components of the famous physics equation:

Force = Mass x Acceleration

Well done, Newton!

TAKE CARE!

If, for some reason, you're doing this inside then make sure you spread out some old newspaper for a landing site. And if you're still worried stiff about the mess – or if you've got the evidence of some 'near misses' on the floor – you could always do the experiment with a golf ball or a stone.

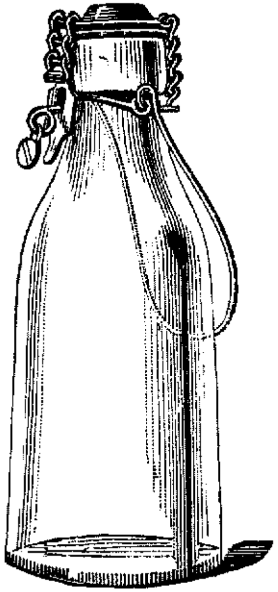


TURNING MILK TO STONE

There's something almost biblical in the title of this experiment, but once you've done it and understood what's happened you'll also be reminded of Little Miss Muffet. Regardless of which reference you prefer (maybe none at all), this demonstration scores high on the 'kewl' scale for youngsters.

• YOU WILL NEED •

- 350 ml skimmed milk
- 4 tsp vinegar
- Microwave
- Microwave-proof mixing bowl
- Strainer



• METHOD •

1. Pour the milk into the mixing bowl.

2. Add the vinegar.

3. Put this mixture in the microwave and cook for one minute.

4. Remove from the microwave to find it now composed of a solid and a liquid.

5. Strain off the liquid.

6. Let the solid cool and then form it into shapes, which harden as they cool.

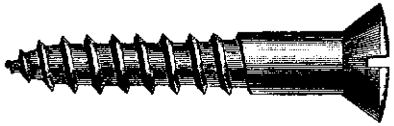
• THE SCIENTIFIC EXCUSE •

The acid in the vinegar separates the curd (the semi-solid element) from the whey (the liquid) in the milk. The protein in the curd accounts for its rubbery quality — in fact, some of the earliest plastics were produced in a variation of this experiment.

• TAKE CARE! •

Make sure that only a responsible person uses the microwave. Otherwise, this experiment is hazard-free.

IRON



BREAKFAST CEREAL

No wonder it was so crunchy! Actually, cereal manufacturers have long played a part in providing us with essential minerals with our daily breakfast. Maybe this experiment could be a springboard to more lucrative exploits: 'There's gold in them thar cornflakes!'

YOU WILL NEED

- Single portion of 'fortified' breakfast cereal (check ingredients for iron)
- Magnetic tape
- Tongue depressor
- Non-metal mixing bowl (500 ml minimum capacity)
- 2 zip-lock sandwich bags
- Water

METHOD

1. Attach the magnetic tape to one end of the tongue depressor and seal it in one of the two sandwich bags.

2. Put the cereal in the other sandwich bag and crush it.

3. Pour this crushed cereal into the mixing bowl and cover with water.

4. Keeping it within the sandwich bag, use the now-magnetic tongue depressor to stir the cereal for 10 minutes.

5. Remove this stirring device from the mixing bowl and observe the tiny metal filings on the outside of it.

THE SCIENTIFIC EXCUSE

Humans need iron and other minerals in their daily diet. Many breakfast cereals are 'fortified' to help us meet this dietary requirement. Normally we wouldn't give this an extra thought, but after seeing the results of the experiment it all seems a little clearer – if perhaps a little less tasty. These iron filings are oxidised in the stomach and absorbed in the small intestine. If all the iron in your body was extracted, you'd have enough to make a couple of small nails.

TAKE CARE!

There's no risk with this experiment, but be patient in the stirring. Ten minutes is a long time but we're talking about small amounts of iron and any less stirring wouldn't be successful.

THE ELECTRIC SPOON

We've all had that nightmare feeling when we've been following a recipe: 'Oh dear! I've mixed the ingredients too soon: they were meant to be separate at this stage.' Imagine if you could turn back the clock and pick the mixture apart bit by bit. Imagine further that you could do this with salt and pepper. Impossible? Read on and think again!

YOU WILL NEED

- 1 tsp table salt
- 1 tsp ground black pepper
- Plastic spoon
- Woollen sock (your hair will do if there's no sock to hand)
- Piece of paper (optional)

METHOD

1. Mix the salt and pepper on a smooth, dry surface.

2. Rub the spoon vigorously against the woollen sock (or your hair).

3. Slowly and very carefully lower the spoon towards the salt–pepper mixture.

4. A few centimetres from the surface, the pepper will jump up, grain by grain, to the spoon's surface.

5. Stop the experiment here if you simply want to show how it works. To complete the separation, continue to steps 6 and 7.

6. Slide a piece of paper under the spoon and shake the pepper grains on to it.

7. Rub the spoon against the wool again and repeat until all the pepper has 'jumped' to the spoon and only salt remains.

THE SCIENTIFIC EXCUSE

Several experiments in this book – including this one – depend on building an electrical flow by rubbing plastic or other substances against wool. As the negatively charged plastic spoon is lowered, it charges the salt and pepper by a process called induction. The nearest surface of the salt and pepper gain a positive charge and the far side a negative. Since 'opposites attract', the grains of pepper and salt jump towards the spoon.

TAKE CARE!

The pepper jumps up first because it's lighter than the salt. That's why lowering the spoon is so important: too fast and the salt and pepper would jump up together. If you want to complete the 'tidying up' after all the pepper has been removed, simply carry on with the process, moving the spoon a bit lower.

'KICK-START' ICE CREAM

Most irresponsible experiments trigger satisfying bangs, smells, oozes and explosions. Not many produce anything that you'd like to eat. This experiment is an exception. It's fun, reckless, runs the risk of being very, very messy – but produces some of the best home-made ice cream that you'll ever taste.

YOU WILL NEED

- 250 ml double cream
- 250 ml whole milk
- 70 g white sugar
- 200 g rock salt
- Large bag of ice (available from most supermarkets)
- Empty coffee tin and its plastic lid (or a lidded plastic container of the same size)
- 15-litre plastic bucket with lid
- 2 tbsp vanilla extract
- A dessert spoon (more than one if you are tempted to share the result)

METHOD

1. Mix the cream, milk, sugar and vanilla in the coffee tin. It should be no higher than halfway up the tin.

2. Put the lid on the coffee tin and put it at the base of the large bucket.

3. Add a 10 cm layer of ice to the bucket in the space around the coffee tin, and then add the rock salt in the same area.

4. Fill the rest of the bucket with ice and affix the plastic lid.

5. Now, get your helpers to kick and roll the bucket around for about 10 minutes.

6. Open the bucket, remove and open the coffee tin. A layer of frozen ice cream will line the inside of the tin. Stir this into the chilled inner liquid to get the right consistency.

THE SCIENTIFIC EXCUSE

The key to the experiment is the salt, which lowers the freezing point of water. Kicking or rolling the bucket causes some of the ice to melt (the friction of knocking together). The water would normally refreeze, but the salt allows it to remain liquid despite being 'below freezing'. This super-chilled water cools the coffee tin, and the ice-cream mixture begins to freeze. The kicking and rolling, however, have the same effect as stirring, preventing huge ice crystals from forming.

TAKE CARE!

Helpers have a habit of becoming overzealous during the 'kick and roll the bucket' phase of this experiment. It's probably a good idea to tape both lids (coffee tin and bucket) firmly in place beforehand.

EGGS IN THE NUDE

TV chefs have always relied on the 'here's one I made earlier' line to take into account lengthy preparation time. If you're planning on demonstrating this experiment to an audience, you might want to adopt the same approach, since a good two days of preparation is needed. (And it takes another day or two to get the real 'payoff'.) The experiment calls for two eggs, although only one is really needed. The extra one is held in reserve, since these 'eggs in the nude' are very delicate without their shells.

YOU WILL NEED

- 2 eggs
- 1 litre vinegar
- 150 ml corn syrup
- Wooden spoon
- Coffee mug
- 1-litre plastic mixing bowl with lid

METHOD

1. Put both eggs in a mixing bowl. Cover with vinegar, put the lid on the bowl and put it in the refrigerator.

2. After about 24 hours, carefully drain the vinegar (the shells will seem mostly eaten away at this point). Replace with fresh vinegar for another 24-hour bout.

3. At this point (48 hours from the start), remove the eggs with the wooden spoon, rinse them and put carefully to one side. Discard the vinegar.

4. Show your audience one of the eggs, holding it carefully with the wooden spoon, and place it in the coffee mug. Then cover it with corn syrup.

5. After another 24 hours, extract the egg and notice how flabby it has become.

6. Now discard the corn syrup, rinse the mug and put the egg back in, covered this time with water.

7. After 24 hours (48 hours from Step 3 and four days from the start) you'll see that the egg is looking healthier again.

THE SCIENTIFIC EXCUSE

There are a few things going on here, all to do with chemistry. To remove the shell and make the eggs 'nude', you immersed them in vinegar. The acetic acid of the vinegar ate away the sodium calcium carbonate crystals of the shell, leaving only the rubbery membrane surrounding the egg. That membrane is slightly permeable, allowing water to move from an area of higher concentration (the egg white, for example, is about 90% water) to one of lower concentration (corn syrup is about 25% water). Replacing the corn syrup in the coffee mug with water reverses this process.

TAKE CARE!

None of the ingredients here is dangerous, so the main advice is one of taking great care in handling the eggs once the shell has been dissolved. The membrane holds things in … just … which is why we recommend having the egg in reserve.

MARSHMALLOWS ON STEROIDS?

Just in case you've spent four days on the last experiment seeing to your 'eggs in the nude', we thought you'd like a real quickie. This experiment is probably one of the quickest and easiest in the book, provided you have a vacuum storage jar (often sold for coffee). And the best thing about it is that you don't lose out in the 'oomph' stakes. You'll never be able to read 'dramatic reductions' again with a straight face.

· YOU WILL NEED ·

- 1-litre storage jar with vacuum pump
- Marshmallows (full-sized fluffy variety)

METHOD

1. Fill the jar nearly full of marshmallows.

2. Cover the jar and pump it to remove as much air as you can.

3. Examine the marshmallows, which should seem puffed up well beyond their original size.

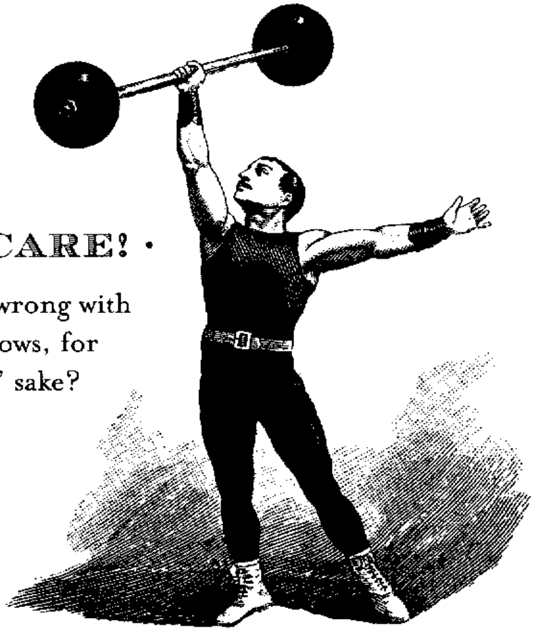
4. Release the pump and observe as the marshmallows return to their original size.

— THE SCIENTIFIC EXCUSE —

Easy, if still dramatic and amusing. Pumping the air out of the container reduces the air pressure inside. When you consider that marshmallows are mainly air bubbles, with some linking solids, you can see how the air in the bubbles would expand to fill the less pressurised air around them. The marshmallow 'solids' (the non-bubble bits) are elastic enough to expand with the bubbles. When you release the pump, the marshmallows shrink back to normal.

· TAKE CARE! ·

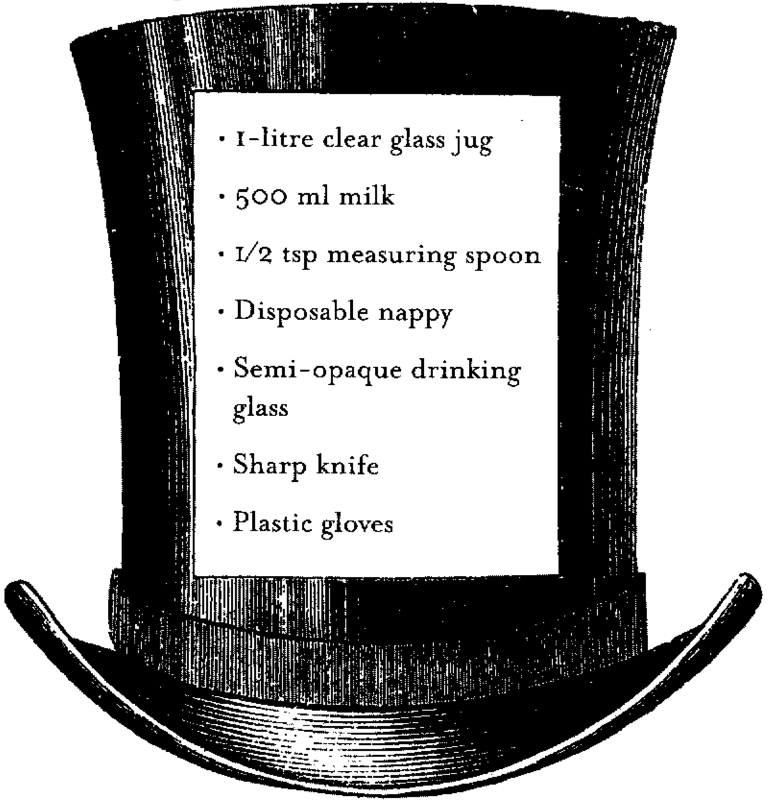
What can go wrong with marshmallows, for goodness' sake?



VANISHING MILK

Several of the experiments in this book are dramatic enough to qualify as magic tricks. This is one of them. Your audience will be dumbfounded as you pour a healthy glass of milk and then make to pour it back into the jug, undrunk. But it's gone! What happened? Is science to blame?

· YOU WILL NEED ·



- 1-litre clear glass jug
- 500 ml milk
- 1/2 tsp measuring spoon
- Disposable nappy
- Semi-opaque drinking glass
- Sharp knife
- Plastic gloves

METHOD

1. Wearing gloves, cut open the centre of a disposable nappy with a sharp knife.

2. Scoop out 1/2 tsp of the powder inside the nappy (known as sodium polyacrylate) and put it in the drinking glass.

3. Pour the milk into the jug. You are now ready to perform the trick for your public.

4. Hold empty glass and full jug out before you, one in each hand.

5. Pour some milk into the glass.

6. Tell your audience that you didn't want the milk, and that you will pour it back. Try to pour the milk from the glass back into the jug. None will come out!

THE SCIENTIFIC EXCUSE

Sodium polyacrylate, the 'active ingredient' in most disposable nappies, is an especially absorbent substance. One test has shown that it can absorb 800 times its own weight in water, which makes up most of the milk. The sodium polyacrylate and milk mix to form a gel, which sticks to the base of the glass. When you turn it over to pour the milk back in, nothing comes out.

TAKE CARE!

Sodium polyacrylate can irritate the eyes and nostrils, so take care when you are dealing with it and also wear gloves. As for practical advice, this experiment works better as a trick if you don't use a clear glass. That way, your audience won't have a chance to notice the milky gel left at the glass bottom.

STRAW THROUGH A POTATO?

Not many of us have experienced the savage force of a tornado. Its 500-kph winds are strong enough to drive a piece of straw clear through a telephone pole. So you can imagine that if you left a drinking straw near a potato as a tornado approached, you might return to find the potato skewered by the straw. But can you imagine getting the same result by hand? Read on, and see how you can do it.

YOU WILL NEED

- Uncooked potato
- Rigid (non-bendy) straw
- Gardening glove (left if you're right-handed or vice-versa)

METHOD

1. Put the glove on one hand.

2. Hold the potato with the gloved hand, pinching it between thumb and index finger.

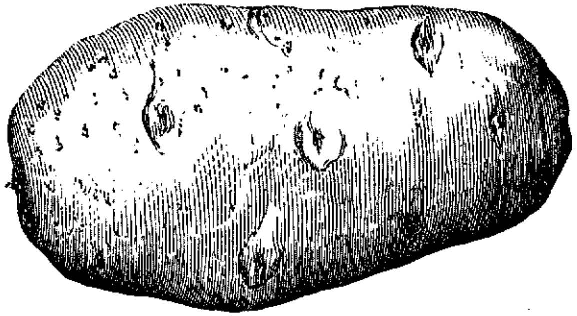
3. Hold the potato steady, pick up the straw (holding it in the middle) and line it up with the potato.

4. Draw the straw back slowly, then stab the straw quickly into the potato.

5. If you're quick enough – and the straw is strong enough – you'll stab right through the potato.

THE SCIENTIFIC EXCUSE

The cylinder shape of the straw gives it surprising strength along through its length, although it remains weak and flexible crossways. That strength, coupled with the narrowness and sharpness of its edge, gives the straw a good chance of making it through the potato with ease.



TAKE CARE!

This is a relatively low-risk experiment, although the same combination of strength and sharpness of the straw could lead to a hand injury if your aim isn't up to scratch. (That's why the gardening glove is called for.)

Peas & Queues

This little gem of an experiment scores high on the 'scientific excuse' side of the equation, offering a real chance to demonstrate – or learn – more about plants. Well, there's the justification out of the way. What the experiment also offers is a chance to capitalise on the spooky 'plip-plop' that others (those who aren't in on the experiment) will find so puzzling and unsettling. Try different positions in the kitchen – or elsewhere – to hide the set-up; see whether you can find somewhere that resonates. You can also try adding a bit of scrunched-up foil to the baking sheet to add a bit of audio variety. With their seeming patience, the peas appear to be queuing up to drop out of the glass.

YOU WILL NEED

- Wine glass (preferably bulb-shaped red-wine glass)
- Thin metal baking sheet or lid (about 20–25 cm wide, either square or circular)
- Dried peas (enough to fill the wine glass)
- Water
- Wide-mouthed (ca 6 cm) drinking glass with a heavy base

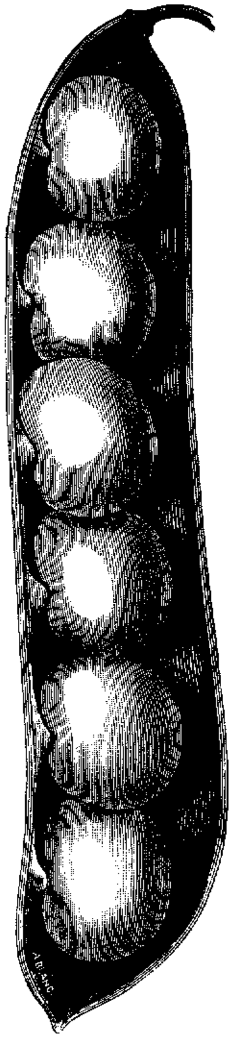
METHOD

1. Fill the wine glass to overflowing with dried peas.
2. Add water right to the brim of the wine glass

3. Place the baking sheet or lid on the stout drinking glass.
4. Put the wine glass on the baking sheet or lid.
5. Slowly, and over the course of the next few hours, the peas will fill with water and begin falling – with a spooky 'plink' – on to the baking sheet or lid.

THE SCIENTIFIC EXCUSE

This experiment is an ideal introduction to osmosis, the process by which water moves from an area of high concentration (the glass) to a lower one (the dried peas). An eager child can get a better grip on how plants draw water upwards from the soil. In this demonstration, though, each pea swells up as it draws in more water. There's literally no more room for these peas, which then tumble out of their position in the wine glass. Holding the baking sheet (on the drinking glass) amplifies each 'plink'.



TAKE CARE!

Make sure you don't leave this arrangement too close to the edge of a counter or on an unsteady surface.

EGG IN A BOTTLE

Here's another take on the scientific principle of creating a vacuum. In this case, it's a hard-boiled egg that gets sucked into a bottle when matches go out. If this is all getting a bit easy, then try the raw-egg variation (see step 5 in the Method).

YOU WILL NEED

- Hard-boiled egg (peeled)
- Matches (long kitchen matches are best)
- 1-pint milk bottle
- Uncooked egg (optional)
- 200 ml vinegar (optional)

METHOD

1. Have a couple of practice runs resting the egg (narrow side down) on the lip of the milk bottle.

2. Light a match and then drop it into the bottle.

3. When the match has almost burned out (judge by the length of the unburnt remainder) place the egg back on the top of the bottle.

4. Watch as the egg seems to be sucked into the bottle.

5. Some people have managed to get the same effect with an uncooked egg which they had soaked for a few hours in vinegar. (The vinegar softens the shell.)

THE SCIENTIFIC EXCUSE

The explanation is pretty simple: the match warms the air, which then expands (some of it escaping) and becomes less dense. Putting the egg on the bottle snuffs out the fire because there is no oxygen supply left. The egg rests between normal air pressure (pushing it down) and weaker air pressure from inside (pushing up against it). No contest – the downward pressure wins the day.

TAKE CARE!

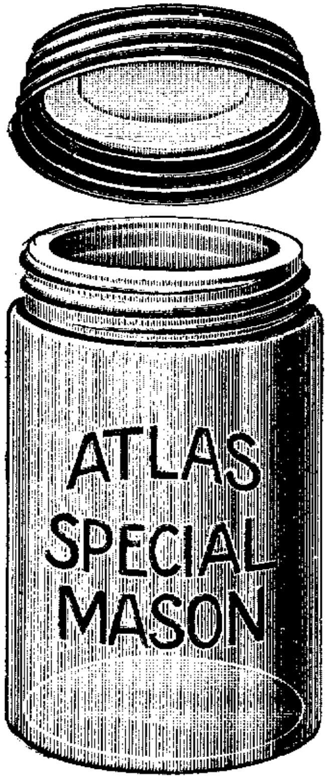
Make sure you do leave the match burning for as long as possible before putting the egg on the bottle. The longer the match burns, the hotter the air inside becomes ... and therefore the greater the difference between the air pressures inside and out.

MATCH ALERT!

This experiment involves the use of matches and should be conducted only by a responsible adult.

SANDWICH IN A JAR

You know how it is: sometimes you just don't like the bread in your sandwich but you love the gooey filling. Wouldn't it be great to be able to get rid of that stale old bread on either side and just concentrate on three spreadable layers? You could even store it in a jar!



YOU WILL NEED

A narrow glass jar with a lid or cork

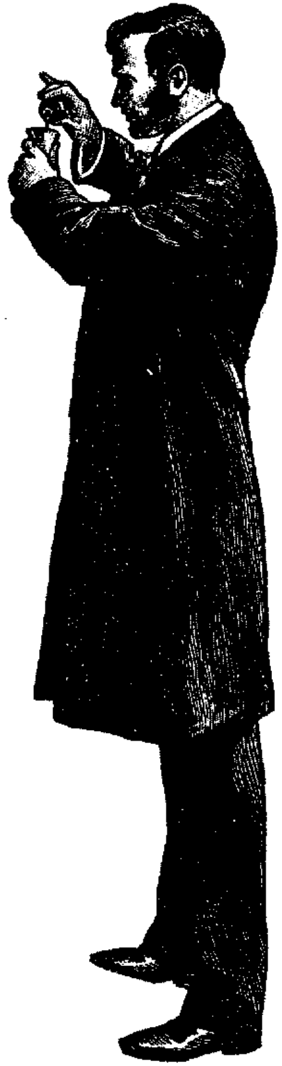
3 tbsp water

3 tbsp cooking oil

3 tbsp honey, treacle or golden syrup

METHOD

Pour the three liquids (water, oil and whichever of the last three you chose) into the jar. Then cover the jar. Within a few minutes, the 'sandwich' will form before your eyes: the liquids separate into three distinct layers.



THE SCIENTIFIC EXCUSE

This is all about density (the amount something weighs in a particular volume). The volume remains the same (3 tbsp) in this experiment, so the densest liquid (the honey, treacle or golden syrup) settles at the bottom. The oil is denser than the water, so it settles in the middle, leaving the clear water layer at the top.

TAKE CARE!

You'd better not take the sandwich idea too far and make anyone eat it!

SUPERSALT!

We cook with it, sprinkle it on chips and popcorn and sometimes preserve food with it. But using salt as a front-line defence seems to be stretching a point. Or does it? Maybe there's more to those little crystals than we ever imagined …

• YOU WILL NEED •

- 100–120 g table salt
- Elastic bands or masking tape
- Cardboard tube (e.g. from paper towel or cooking foil)
- Greaseproof paper
- Broomstick or wooden dowel (narrow enough to fit inside the cardboard tube)
- Scissors

METHOD

1. Cut two squares of greaseproof paper (each 15 cm x 15cm).

2. Use an elastic band or masking tape to fix one of those squares to one end of the tube. (It should be spread taut over the end like the skin on a drum.)

3. Feed the broomstick or dowel into the other end and then push through – note how easily it breaks through the paper.

4. Remove the torn paper and replace it with the second piece you had cut.

5. Now fill the tube up with about 8–9 cm of salt.

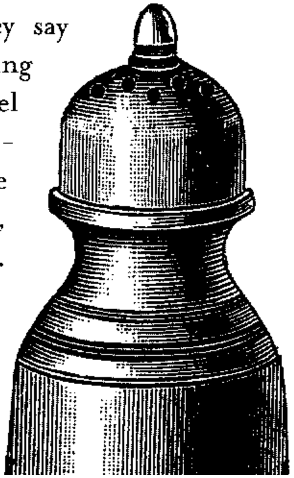
6. Try plunging the broomstick through again. Wait for the salt to spray out … but maybe it won't!

THE SCIENTIFIC EXCUSE

This experiment is all about the direction of force. With no salt to block it, the broomstick will easily pierce the greaseproof paper at the end of the tube. The addition of the salt, however, changes the rules. The thousands of crystals deflect the force, channelling it away from its original course and spreading it out towards the edge of the tube – rather than towards the thin paper at the end.

TAKE CARE!

'Everything in moderation', as they say about so much in life. Someone trying to recreate the force of a Channel Tunnel train might succeed in breaching the salt defence, but the whole point here isn't to test our strength, but to observe the strength of the salt.



CARROT FIRST AID

Wouldn't it be wonderful to be able to give the 'kiss of life' to wilted, droopy vegetables? This experiment gives you the chance to do just that, giving a limp carrot the chance to 'stand up and be counted' once more – or at least to feel a little more solid.

· YOU WILL NEED ·

- Good-sized carrot which has become limp
- 300-ml drinking glass (clear)
- Small cup
- Clear plastic straw (cut to a 3-cm length)
- 4 toothpicks
- 1 tsp water
- 1 tsp of sugar
- Plasticine

METHOD

1. Fill the glass about 3/4 full of water.

2. Hollow out the top of the carrot (about 1 cm square and 1–1.5 cm deep).

3. Set the length of straw into this hole and seal the edge with Plasticine.

4. Stick the toothpicks at even distances into the sides of the carrot near its top and rest these on the rim of the glass, with the carrot mainly submerged.

5. Mix the sugar with the equal amount of water in the small cup and fill the straw (which juts out from the carrot) about halfway up.

6. Observe in an hour or two – the water level in the straw should have risen.

THE SCIENTIFIC EXCUSE

This experiment is all about the process called osmosis. Water passes through plant-cell walls as it moves from an area of high concentration (of water) to an area of lower concentration. In this case, the carrot has become limp because it has lost much of the water that gave it strength. While in the glass, it absorbs water from its surroundings, becoming more rigid again. In a growing carrot, some of this water would be channelled upwards through the top of the orange bit; the addition of the straw (as a sort of gauge) shows how this water level rises.

TAKE CARE!

There's no danger inherent in this experiment. Make sure, though, you use a sugar solution in the straw: ordinary water might evaporate.

FROZEN BUNS

The craze for streaking – dashing naked through a public place – began in the 1970s. Streakers seemed to find their way into all sorts of public places, particularly sporting and entertainment events that were being televised live.

During the 1974 Academy Awards broadcast, for example, Robert Opel streaked across the stage and flashed the peace sign at the millions watching the programme. Presenter David Niven was momentarily stunned but then joked: 'Isn't it fascinating to think that probably the only laugh that man will ever get in his life is by stripping off and showing his shortcomings?'

Most major sports have had their share of streaking attacks as well. Two of the most lasting images of streaking come from Twickenham, the home of English rugby. One of the most reproduced sporting photos in journalistic history shows police escorting 25-year-old Michael O'Brien from the pitch – with a policeman's helmet strategically placed – during the England-France match in April 1974. Eight years later, Erica Roe disrupted an England-Australia match by streaking topless onto the pitch.

Not all streakers choose to bare all in such public arenas. So it was particularly unlucky that a good-natured streaking trio in Spokane, Washington wound up paying a large price for their prank in January 2004. The three young men (whose names are protected under Washington reporting restrictions) had planned everything to the last detail – or so they thought.

They pulled into the car park of a Denny's restaurant at 5 am. Leaving their car running so that they could make a quick getaway, they jumped out into the –10°C air and dashed through the restaurant wearing only hats and running shoes. But during the brief commotion, one of the Denny's customers left, got into the car and drove it away.

When the police arrived some minutes later, the three young men were huddled together, shivering behind one of the other cars in the car park. 'I don't think they were hiding. I think they were just concealing themselves,' police spokesman Dick Cottam said. 'We always tell people not to leave their car running,' he added.

THE SHY ARSONIST

This little gem of an experiment delights and mystifies within a matter of seconds. No matter how you slice it, the conclusion seems to be that the residue of an experiment is what is needed to get the experiment going in the first place. Which came first – the fire or the ash?

YOU WILL NEED

- A sugar cube
- A brick or other book-sized fireproof object
- Matches
- Ash from a bonfire or fireplace

METHOD

1. Put the sugar cube on the brick (or other fireproof object).

2. Try to light it with a match – it won't catch fire.

3. Spread a little ash over the cube and try again.

4. This time the cube lights easily and will have a lovely blue flame.

THE · SCIENTIFIC · EXCUSE

The ash in this experiment is obviously vital. Although it remains unchanged after the experiment, it provides enough initial energy for the sugar to combust. Ingredients that 'kick start' experiments, while playing no part in the main chemical reaction, are called catalysts.

· TAKE CARE! ·

Make sure that the fireproof base for this experiment is well away from curtains, furniture or any other household objects that could catch fire.

· MATCH ALERT! ·

This experiment involves the use of matches and should only be conducted by a responsible adult.

- THE -
TIPSY ICE CUBE

This is an ideal experiment to try out when some guests have arrived and are chatting over a glass of whisky. One look at the madcap ice cube in this glass will have them wondering just how much they've drunk. But be sure to spare them a hangover by explaining the science behind this wicked little trick.

YOU WILL NEED

- Tall drinking glass
- Cooking oil
- Ice cube

METHOD

1. Fill the glass almost to the top with oil.

2. Add an ice cube to the glass.

3. Leave the glass and observe.

4. The ice cube will begin to rock back and forth and even bob up and down without any outside shaking of the glass.

THE SCIENTIFIC EXCUSE

The ice cube and the oil have roughly the same density, so at first the cube sits motionless on the liquid, as it would in a normal drink. But inevitably the ice begins to melt. Water is actually denser than ice (and oil), so a drop of melted water forming at one end of the cube causes the cube to tilt until the drop flows off. If enough water remains on the surface of the ice, the cube will even begin to sink – that is, until the water is washed off and the ice returns to its normal density. Then it floats back to the surface.

TAKE CARE!

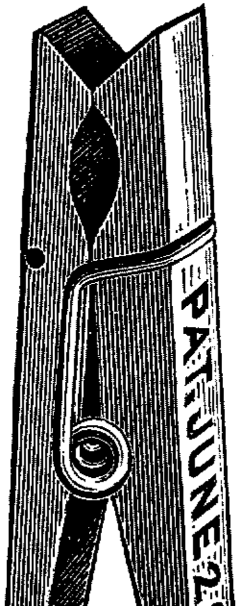
Apart from incurring the wrath of a house guest, this experiment is unlikely to get you into any real trouble. Although the experiment itself is easy enough to perfect, you might want to tinker with it a few times beforehand to get a good whisky (or other drink) colour. Try mixing a drop or two of food colouring in with the oil to get the right look.

THAT'S TASTELESS

A quick look at this experiment being performed would lead most people to conclude that it was a game of blind man's bluff. But the blindfold is really just an extra precaution. The core of the experiment lies in hoodwinking other senses – taste and smell, to be precise. The results are usually astounding, even if the subject is none too pleased when you bring them up to speed at the end. This is a great experiment in its own right, but so much better if you can get a willing volunteer to be put to the test.

YOU WILL NEED

- Onion (kept in another room until step 4 below)
- Knife
- Blindfold (dark-coloured cloth about 60 cm square, rolled so that it can be tied behind someone's head)
- Handkerchief
- Large clothes peg
- Volunteer
- Witnesses
- Tissue (optional)
- Tweezers



METHOD

1. Reassure your volunteer that everything you do will be safe. Explain that you will need to blindfold them and peg their nostrils shut – but that it won't hurt.
2. Gently tie the blindfold behind your volunteer's head.
3. Take great care pegging the volunteer's nostrils shut with the clothes peg; slide some tissue between the peg and their nose to act as a cushion if it begins to hurt.
4. Go to the other room and cut off a piece of onion about half the size of a stamp. Put it on a small plate.
5. Return to the first room and ask the volunteer to hold out his or her tongue.
6. Use tweezers to place the onion on the middle of the volunteer's tongue.
7. Ask the volunteer to identify the object – they almost certainly won't be able to do so.
8. Unclip the peg on the volunteer's nose.

THE SCIENTIFIC EXCUSE

This experiment demonstrates how we need our sense of smell to identify many tastes accurately – you might have had the same problem when your nose has been stuffed because of a cold.

TAKE CARE!

There's no need to tie the blindfold very tight at all – just make sure it stays over the volunteer's eyes.

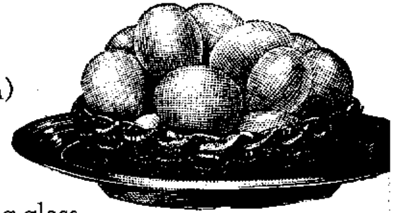
THE FOLDING EGG

Recipes often call for the cook to 'fold an egg into the mixture' – usually when people are making some sort of batter or dough. Of course, the word 'fold' has a special meaning in such recipes – to cut and mix lightly to keep air in a mixture. But imagine what fun you could have if someone were reading those words out from a recipe, and you really did fold an egg, right in your hand!

Readers of *Wholly Irresponsible Experiments* might have a head start with this experiment, which shares some of its magic with 'Eggs in the Nude'. But this time it's given a new twist – or fold.

YOU WILL NEED

- Several fresh eggs (only one is needed but you might need a spare or two)
- Drawing pin or sewing pin
- Long needle (more than 6 cm)
- Vinegar
- Bowl
- 400 ml beaker or tall drinking glass



METHOD

1. Make small holes with the pin on either side of the egg.

2. Use the needle to probe the inside of the egg, swirling and mixing the white and yolk together (you want to make it into an easy-to-pour liquid).

3. Blow on one of the holes so that the inside of the egg (the mixed white and yolk) flows into the bowl. You can use this for a real cooking recipe, by the way. The egg should be empty now.

4. Put the empty eggshell carefully into the beaker or glass and cover it with vinegar. You might need to persuade it to sink by holding it down until it fills with liquid.

5. Leave the egg as it is for about a week. Note how bubbles float off its shell.

6. You want all of the outer shell gone (dissolved), so wait until no more bubbles seem to be forming.

7. Take the egg out and rinse it gently under cold water. It is like the 'egg in the nude' except that it is hollow. Gently squeeze the water out and blow it up again as in step 3.

8. At this point, an observer might think that it is a real egg, so when your friend asks you to fold the egg you can hold this one and simply fold it in your hand.

THE SCIENTIFIC EXCUSE

The vinegar, which is a mild acid, eats away at the hard calcium carbonate eggshell to reveal an inner layer – the membrane that acts as a seal around the yolk and white. That membrane is delicate but still strong enough to be held carefully.

TAKE CARE!

Stages 1, 2 and 3 are the hardest in this experiment. Don't be discouraged if it doesn't work the first – or second – time. That's why you have the spare eggs.

COLOUR ME CONFUSED

It's one thing hoodwinking our sense of taste by denying it the sense of smell (see 'That's tasteless!', page 130). That's a wonderful trick, but you could argue that because those two senses are physically linked, the result wasn't too surprising. Plus, the volunteer in that experiment was blindfolded. How about trying a variation on the theme, only this time letting your subject approach the task with both eyes wide open? Can you still pull a fast one?

YOU WILL NEED

- Six identical drinking glasses
- Either six distinctly flavoured but clear fizzy drinks (such as lemonade), or sparkling water with six flavour essences dropped in them (such as mint, almond, coffee etc.)
- Six strongly coloured food colourings
- Volunteer

METHOD

1. Fill each glass with a different drink and line them up. (Note which drink was which so that you can check on the results.)

2. Ask the volunteer to taste each one and try to identify it. Don't give away the right answer, but record the volunteer's.

3. Ask the volunteer to leave the room or turn around.

4. Top up each drink to the same height and then put a few drops of colouring in each one. Make sure the colouring doesn't 'match' the colour we'd normally expect of the drink (make the lemonade blue, for example).

5. Line the drinks up in a different order and ask the volunteer to try again.

6. Check the volunteer's results – they'll probably have got some of them very confused.

THE SCIENTIFIC EXCUSE

Although we don't need to see something in order to taste it, our eyes can send some expected results through to the brain before something even goes into the mouth. Companies recognise this, which is why a lot of those 'E' numbers that appear on lists of ingredients are actually artificial colours to make a food or drink more appealing.

TAKE CARE!

Make sure that the essences that you add are genuine food essences. Also make sure you use them sparingly (only a couple of drops) because the flavour is so concentrated.

– THE –
DNA DETECTIVE

'A half-eaten banana was found near the door of the safe that had been blown open.' What would Sherlock Holmes have done with that piece of evidence, found at the scene of a multi-million-pound bank robbery? Even he would have been stumped if there were no way of linking the banana with the suspect being held in the police cells.

Modern detectives have a few more tools to use, and one of them is DNA analysis. DNA is the chemical 'blueprint' of every living thing – what makes it different from every other living thing. People leave traces of their DNA on things that they touch or eat, so the first step is to extract the DNA from the banana that the safe-cracker was eating. But how do you set about doing that? Elementary, my dear Watson.

YOU WILL NEED

- Half-eaten banana
- Food processor
- Salt
- Cup
- Hot water
- Washing-up liquid
- Methylated spirits
- Paper coffee filter
- Wooden skewer
- Clear drinking glass
- Teaspoon

METHOD

1. Put the banana into the food processor.
2. Add a teaspoon of salt to half a cup of hot water.
3. Pour the salt-water mixture in with the banana and process for one minute. Rinse the spoon and cup.
4. Pour the mixture through a sieve back into the cup. Press the back of the spoon against the sieve to push the solids through.
5. Add a teaspoon of washing-up liquid. Stir occasionally for 5 minutes.
6. Set the coffee filter over the drinking glass and pour the mixture into it, so that it drips into the glass.
7. Slowly pour methylated spirits down the side of the glass until it forms a 1-cm layer on the top of the mixture.
8. A layer of fluffy white material should form between the mixture and the methylated spirits.
9. Use the toothpick to extract some of this material (which is the DNA); with any luck, you'll be able to pick out a strand of DNA.

THE SCIENTIFIC EXCUSE

DNA, like other chemicals, is stored inside cells. Processing the banana helped break down some of these protective barriers; the washing-up liquid helped dissolve some other chemicals that were locking the DNA inside. DNA dissolves inside water-based mixtures, but doesn't dissolve in alcohol. The fluffy material at the end of the experiment was DNA that was not dissolving in the alcohol.

TAKE CARE!

Make sure that it is an adult who handles and pours the methylated spirits.

NON-STICK PAN?

Just in case you're performing the experiments from this book in order, you'll probably need a little light relief after all your forensic efforts in the DNA experiment (see previous pages). How about something that's funny, informative, challenging ... and quick? It might also let you get your own back on that muscle-bound friend who's always bragging about how strong he is.

If you're planning to do this one as a trick, finish steps 1–3 before calling your friend in.

YOU WILL NEED

- Perfectly smooth work surface (formica or vinyl, or even marble will work)
- High-sided baking tray
- Water
- Cloth

METHOD

1. Pour some water (equivalent to about half the area of the baking pan) onto the work surface.

2. Spread this out to match the shape of the base of the baking tray. Add a little more water to make sure all the whole of the underside of the tray will be wet if you put it down there.

3. Put the baking tray down on that wet spot, and dry any bits that jut out from under the pan.

4. Pretend to be reading a recipe and ask your friend to pick up the baking tray carefully, to see how much it weighs (let them puzzle over why you'd need to know that).

5. Watch as their face goes through a bizarre set of expressions ... the baking tray seems glued to the counter!

THE SCIENTIFIC EXCUSE

A scientific principle called adhesion causes water to seem sticky (don't forget, the real name for sticky tape is 'adhesive tape'). This stickiness can be up to 200 times stronger than normal air pressure, which we know is pretty strong because it powers a lot of the experiments in this book.

TAKE CARE!

Don't provoke anyone who's too strong – in case they really take it the wrong way.

GLOWING GRAPES

Pressed for time and keen to show off some of your powers as a wizard? Try this spectacular experiment, which will produce glowing results in just a few seconds. The materials couldn't be simpler, but you might want to bone up on your electromagnetism if you want to provide a satisfying explanation for this bit of kitchen 'lightning'.

YOU WILL NEED

- Microwave oven
- Seedless grapes
- Sharp knife
- Microwave-safe plate or saucer

METHOD

1. Cut a single grape almost into two halves, leaving a small flap of skin connecting the halves.
2. Put the connected grape halves on a microwave-safe plate or saucer and place in the microwave oven.
3. If the oven has a turntable, try to position the grapes in the exact centre.
4. Turn the oven on at high power for ten seconds.
5. Within about five seconds, a bright light (accompanied by an audible buzzing) develops in the 'bridge' between the grape halves.

6. After a few more seconds, the grapes begin to emit sparks and a glowing arc or cloud rises from them. The effects then disappear.

THE SCIENTIFIC EXCUSE

Although this experiment is one of the simplest in this book to perform, the scientific explanation is probably the longest and most complicated. Boiled down (excuse the pun), the science is as follows:

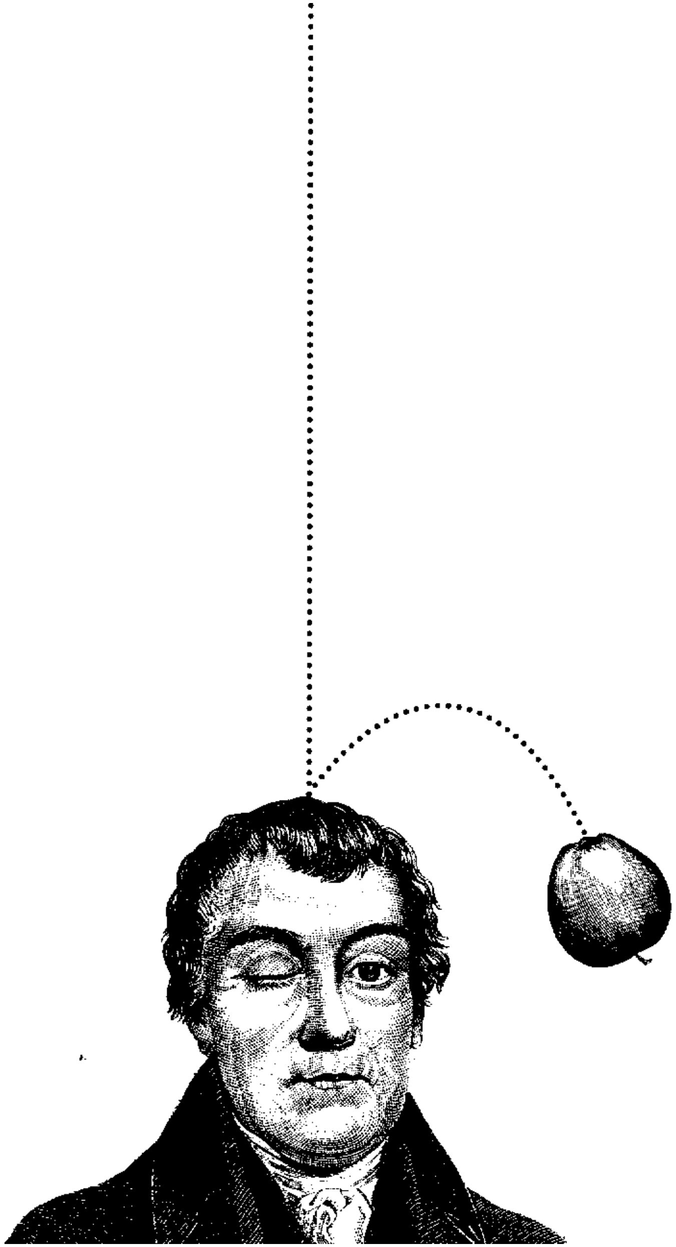
First of all, note that grapes are reasonable conductors of electricity. That means that when the microwave is turned on, it not only heats the water inside the grapes but also causes some electrical charge to move from grape half to grape half across the skin 'bridge'. This electrical current releases energy as it passes through, so the bridge becomes very hot, eventually catching fire.

As the electrical current now passes through this flame, it ionises (removes electrons from) the gas. At this point, the gas (flame) is conducting electricity; it produces a glowing arc or cloud, a similar effect to the St Elmo's Fire that sailors observe on ships' masts in stormy weather.

The effect dies down when all of the water from the grapes has evaporated, killing the flow of charge, or when the power timer shuts the oven off.

TAKE CARE!

Be warned: there is a slight chance that this experiment will damage the microwave. As a basic precaution, don't be tempted to leave the microwave on for longer than the ten seconds.

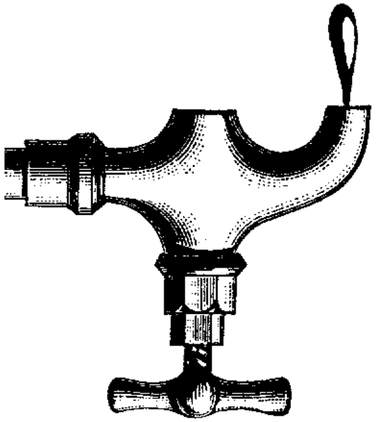


HOW MOVING!

Can you remember Sir Isaac Newton's First Law of Motion? His Second? His Third? Don't worry if you can't, because you'll be demonstrating some of them yourself if you carry out some of the following experiments. Everyone loves a chance to build something that rolls, flies, hovers or blasts off. And to do that in the cause of science – with an eager audience cheering you on – well, that's a little bit of heaven.

ANTI-GRAVITY WATER

We're all aware – even unconsciously – of the forces of motion that govern the world of physics around us. Most of us have slid towards the side of a car as it rounded a bend or even, as children, leaned into a curve as we sped on our bikes. Here's a chance to get to the root of that 'force of nature'. Give it a whirl. Cheers!



• YOU WILL NEED •

- 18 cm x 18 cm square of stout card
- 2 x 1-m string
- Hole punch
- Plastic or polystyrene cup
- Some coins (optional)
- Water

METHOD

1. Punch holes about 2 cm in from each corner of the card.

2. Feed one end of a piece of string up through one of the holes, and the other piece of the same string up through the hole diagonally opposite.

3. Repeat step 2 with the other piece of string so that you have formed a string 'X' at the base of the card. Lay the card somewhere flat.

4. Ensure that the four upward-leading strings are the same length, then tie them so that you can pick up the card 'tray' evenly by holding the knot and lifting.

5. Half-fill the cup with water and put it in the centre of the tray.

6. Holding the knot, lift the tray and then whirl it round. None of the water should spill out, even if you whirl it in a vertical 'orbit'.

7. With the whirling still vertical, slow the speed down carefully and pluck the cup from the tray before it falls off. If you've got the knack, none of the water will have spilled out in the experiment.

THE SCIENTIFIC EXCUSE

You have just been demonstrating Newton's First Law of Motion: 'An object in motion will remain in motion unless acted upon by an external and unbalanced force.' In this case, swinging the cup sends its contents outwards. The tension of the string exerts the 'external force', causing the cup to move in a circular path. The water, however, continues to try to move in a linear (straight) path, so it is pushed against the base of the cup. The inward movement of the cup is called centripetal force.

TAKE CARE!

The risks here are pretty obvious, so you should do this experiment outside, where there's no need for a clean-up or public hearing if things go a little wrong. And if you're really in the mood to tone down the irresponsibility even further, try using a few coins in the cup instead of water.

FLOATING AWAY

'It's all just smoke and mirrors.' This expression, once confined to the music-hall critic's assessment of conjurors' performances, has entered the language to imply any trickery that leaves audiences confused or bemused. Well, this book has helped readers use – or produce – smoke to get some dramatic results. Now how about a little mirror work? It's a bit time-consuming setting it up, but you'll be able to use the set-up again and again. This experiment (or trick) is best done with an audience, so keep them mum about the preparations and secret.

YOU WILL NEED

12 lengths of wood (75 cm x 2 cm x 2 cm)

Panel pins or wood adhesive

1 m x 1 m square mirror

METHOD

1. Construct a wooden cube by joining the 12 lengths of wood held together with the panel pins or wood adhesive.

2. Find a table that will hold your weight and will have enough room to hold the cube. Position a chair near it (so you can climb onto the table easily), all the while ensuring that your audience is in another room – or behind a curtain, if you're feeling theatrical.

3. Put the cube on the table, then slide the mirror straight down into it. The mirror should be upright (mirror side facing your audience) and positioned diagonally when seen from above.

4. Mount the table and step into the cube, straddling the mirror. Stand still.

5. Invite your audience in, or draw the curtain.

6. Begin a series of slow movements with the leg that's in front of the mirror, keeping the other leg firmly in place for support.

7. The mirror will make it look as though both your legs are leaving the table, so capitalise on this optical illusion by pretending to float away, swim in mid-air, etc.

THE SCIENTIFIC EXCUSE

This is, of course, all down to the optical illusion created by the mirror. In strict scientific terms, light travels from your visible leg to the mirror and is reflected outwards, making people perceive it as your 'other' leg – which, of course, is firmly on the ground.

TAKE CARE!

Does this book need to remind you about the risks involved in breaking mirrors? Make sure the mirror is reasonably secure as it rests against the wooden cube. Any play in the mirror would ruin the effect.

FILM CANISTER ROCKET

Harness the powers of chemistry and call in the aid of Sir Isaac Newton to send your home-made rocket ... well, not quite into orbit but at least zooming off its kitchen launch pad. This experiment can be a group effort from start to finish, from the cutting of the fuselage to providing the voice for the 'final countdown'.

YOU WILL NEED

- Film canister with click-shut lid
- Coloured paper (lightweight)
- Several sheets of toilet tissue
- 3 tsp lemon juice per flight
- 1 tsp bicarbonate of soda per flight
- Scissors
- Sticky tape
- Glue
- Teaspoon

METHOD

1. Cut a piece of coloured paper to about 12 cm x 6 cm: this piece will become the fuselage.

2. Line the long end of this piece of paper along the open end of the canister and tape it on lengthways, keeping the open end clear of any tape.

3. Roll this paper around the canister (it overlaps a bit) and tape it into a secure cylinder. (One end of the paper cylinder should be flush with the open end of the canister and the other end extends past the closed end.)

4. Cut a circle of 4 cm diameter from more coloured paper, and then cut a pie-shaped segment that's about 1/8 of the circle. Tape the larger piece that you are left with shut: this will be the nose cone.

5. Glue the nose cone to the end of the cylinder (be sparing with the glue, to minimise weight).

6. Cut three triangles to form old-fashioned 'fins' for the base of the rocket. Fold each triangle slightly to create a narrow flap. Glue each flap at equal distances on the sides at the base of the rocket.

7. Hold the rocket upside-down and add the lemon juice.

8. Stretch a piece of toilet tissue over the open end of the upturned rocket. Pinch it to the edges of the rocket so that it is held lightly across the opening (with some slack – but not touching the lemon juice).

9. Pour 1 tsp of bicarbonate of soda into the slack and – still holding the rocket upside-down – replace the lid. Trim off any excess paper.

10. Turn the rocket over slowly and place it on the prepared launch site. Stand back and wait: take-off is usually within 20 seconds.

THE SCIENTIFIC EXCUSE

The reaction between the lemon juice (an acid) and the bicarbonate of soda (a base) produces carbon dioxide. This gas builds up pressure inside the canister until it blows the lid off the bottom. That's where Newton's Third Law of Motion ('For every action there is an opposite and equal reaction') comes into play. The canister is blown upwards with an equivalent force to the one that blew the lid down. Lift-off!

TAKE CARE!

Make sure you your launch site is on a waterproof (or water-resistant) tablecloth or a floor that won't be stained easily. The timing of the launch (once the ingredients are inside) can be a little hard to predict, so take care not to be directly above it. The chemistry behind the propulsion is fail-safe, so if your rocket fails to launch, examine it to see whether it's too heavy. If so, modify it by reducing the size of its components or the amount of tape or glue used: see if it works now.

TENNIS BALL MOON BOUNCE

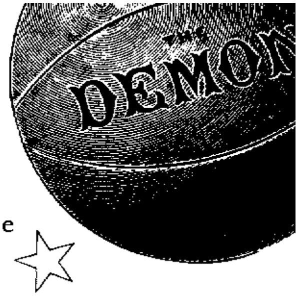
Can physics really be this much fun? How in the world can you manage to bounce the tennis ball that high? Expect physics faculties to be stormed by applicants in the next few years after you've given this demonstration a few times. You'll need three things to make the experiment work well: a steady hand, a hard surface (for a good bounce) and space. It's best performed on a driveway or in a car park.

YOU WILL NEED

- Tennis ball
- Basketball (a football or volleyball will work, but not as dramatically)
- Golf ball (optional)
- Table-tennis ball (optional)
- Cardboard tube (optional)

METHOD

1. Hold the basketball out at chest height and drop it: note how high it bounces.
2. Repeat with the tennis ball.
3. Now hold the two together at arm's length, with the tennis ball above the basketball and touching it on the top (at the 'north pole' of the basketball).



4. Drop the pair and note how high the tennis ball bounces.
5. If it's hard to get the alignment right, try using a golf ball beneath a table-tennis ball.
6. And if it's still difficult, hold the golf ball and table-tennis ball inside a cardboard tube (to align them with each other and vertically): this should make it easier to perform.

THE SCIENTIFIC EXCUSE

This is a wonderful demonstration of Conservation of Momentum. Momentum can be expressed as mass times velocity. When the balls collide, their momentums are equal, but because the mass of the basketball is so much greater, the tennis ball acquires a much greater velocity to balance the equation. The result: it shoots off to space. The same principle applies to a cricket bat (massive) hitting a ball (less massive): the ball goes sailing for a six while the bat remains in the batsman's hands.

TAKE CARE!

Provided you've given yourself enough space to perform this experiment (i.e. outside), there should be no concerns. Otherwise, we'd be looking at four sports that would face bans on the grounds of safety.

DANCING MOTHBALLS

If the Mexicans can have jumping beans, then why can't you have dancing mothballs? Just a few easy steps and you'll see how easy it is. And how in the world is all of this irresponsible? Well, just look at those ingredients and imagine how your kitchen will smell after you mix them. How popular will you be then?

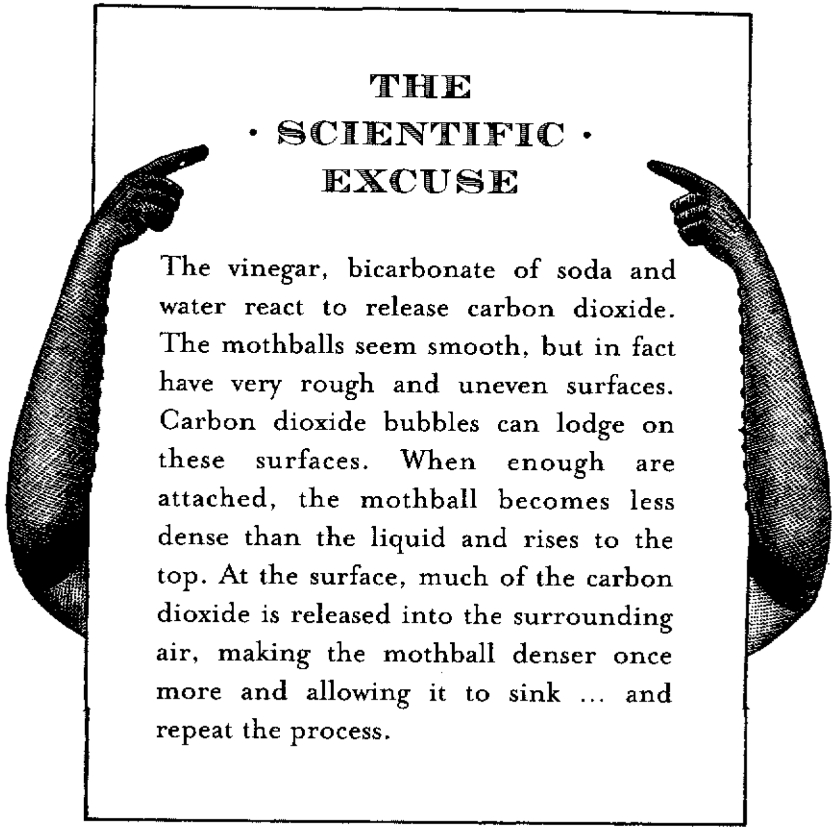
YOU WILL NEED

- A wide-mouthed glass jar or drinking glass
- Several mothballs
- 60 ml vinegar
- 10 ml bicarbonate of soda
- Water

METHOD

1. Fill the jar or glass with water, leaving 2 cm at the top.
2. Add vinegar and bicarbonate of soda and stir gently.
3. Add two or three mothballs.

4. Watch as the mothballs slowly 'dance' – sinking first, then slowly rising, then sinking again.



THE · SCIENTIFIC · EXCUSE

The vinegar, bicarbonate of soda and water react to release carbon dioxide. The mothballs seem smooth, but in fact have very rough and uneven surfaces. Carbon dioxide bubbles can lodge on these surfaces. When enough are attached, the mothball becomes less dense than the liquid and rises to the top. At the surface, much of the carbon dioxide is released into the surrounding air, making the mothball denser once more and allowing it to sink … and repeat the process.

TAKE CARE!

This is a fairly 'low-risk' experiment. The biggest concern is discarding the liquid and its contents afterwards so that the next person in the kitchen isn't tempted to drink it!

THE CD HOVERCRAFT

It's everyone's dream to be able to glide around as if they were on a flying saucer. That type of friction-free movement does, in fact, lie at the heart of hovercraft technology. This experiment lets you use everyday objects as a gateway to this brave new world of transport. Be careful, though: get your answer straight before you hear: 'What have you done to my new Amy Winehouse CD?'

YOU WILL NEED:

- Ordinary CD or DVD
- Plastic bottle cap
- Strong glue
- Balloon

METHOD

1. Make a 10–15 mm hole in the centre of the cap.

2. Glue the cap to the centre of the CD or DVD, so that the holes align (and so that the flat of the cap is touching the CD).

3. Blow up the balloon and twist the end tight (but not tied).

4. Carefully roll the balloon's 'lip' over the edge of the cap.

5. Place the CD on a smooth surface and release.

6. The 'hovercraft' should slide easily along the surface after having had the slightest touch.

THE SCIENTIFIC EXCUSE

Air rushes out of the balloon through the hole to provide an 'air cushion' below the CD. This cushion supports the entire lower surface of the CD because air is escaping on all sides. And without the friction of rubbing against the surface (the air cushion has eliminated it), the 'hovercraft' can move freely. The same principles enable real hovercrafts to transport passengers and cars across open water.

TAKE CARE!

Be careful not to use too much glue when attaching the cap to the CD (you might block part of the hole). And, as mentioned already, don't use anyone's precious new CD!

TWO-STAGE ROCKET

The NASA website points out how rocket technology is just a variation on balloon technology, so mastering a two-stage balloon rocket should put you in the same engineering elite who produced the NASA space shuttles and the proposed Mars missions. It's wonderful to think that some of the same scientific principles are at work in this common-or-garden demonstration that anyone can master. It's not rocket science after all, or is it?

YOU WILL NEED

- 2 volunteers
- 2 long, narrow party balloons (inflatable to around 60 cm)
- 25–30 m clear fishing line
- 2 x 3-cm lengths of drinking straw
- Masking tape
- Scissors
- Empty 1-litre plastic bottle

METHOD

1. Thread the two lengths of straw on the fishing line.

2. Tie the line taut, attaching it to two strong objects such as trees or clothes lines.

3. Cut a ring of plastic 2 cm wide from the middle of the plastic bottle.

4. Blow up one of the balloons and pinch its end shut; press this pinched end to the inside of the plastic ring. (This first balloon will become the second stage of the rocket.)

5. Continue holding the pinched end of the first balloon against the ring while you insert the second balloon partway through the ring.

6. Now blow up the second balloon, eventually letting go of the first balloon's end when it has been pressed to the inside of the ring by the second balloon.

7. Pinch the end of the second balloon: you should now have a 'two-stage balloon' in your hands.

8. Have the second volunteer attach each balloon 'stage' to a straw section (which is free to slide along the fishing line). Continue pinching the end of the second balloon while you pull the combination back to the end of the line.

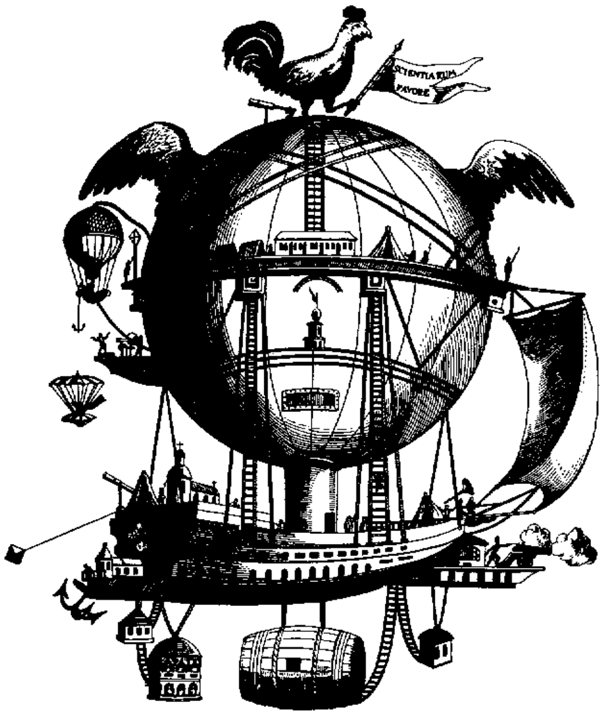
9. Release the balloon and it should speed off down the line, discarding the first stage (the second balloon you inflated) along the way.

THE SCIENTIFIC EXCUSE

'For every action, there is an opposite and equal reaction.' This principle, observed by Newton, lies at the heart of rocket (or in this case, balloon) science. Letting go of the balloon allows the high-pressure air to rush out into the less pressurised air around it. But this rushing out provokes an opposite force which propels the rocket forwards. The same process is repeated when the first stage is depleted and it's the turn of the second stage to push ahead.

TAKE CARE!

This experiment works best (the stages travel further) if the fishing line is very taut and also level. This reduces friction along the track.



SOMETHING IN THE AIR

Politicians don't have a monopoly on hot air. Scientists can give them a run for their money; plus they can do a lot with cool air, cold air and all sorts of other gases. Test-drive some of the following suggestions and you'll see why. Sure, these experiments carry an element of risk and edginess. But at least they're not likely to land you in a Russian labour camp – the fate that befell the young German pilot whose day trip to Red Square turned out to be one-way.

– THE –
HOVERING BALL

Have you ever phoned a hairdresser and tried to book yourself in for a 'Bernoulli'? No? Maybe you should, because hairdressers have a tool to demonstrate one of the most far-reaching principles of physics, first noted by Swiss scientist Daniel Bernoulli in the 18th century. Take 30 seconds to grasp the essence of Bernoulli's timeless observation. In the meantime, have a ball!

YOU WILL NEED

- Hand-held hairdryer
- Table-tennis ball
- Cardboard tube

METHOD

1. Set the hairdryer to a low temperature but high speed and point it upwards.
2. Lower the ball into the upward flow of air and let go.

3. Watch as the ball remains suspended.
4. With the ball still suspended, lower the cardboard tube down towards it slowly.
5. The ball will be sucked up into the tube.

THE SCIENTIFIC EXCUSE

This experiment, like some others in this book, works because of Bernoulli's principle (see p. 165). Bernoulli, noted that a gas or liquid loses pressure as it gains speed. In this case, the air moves from the hairdryer and around the ball, and this moving air has low pressure. The pressure remains unchanged (stronger) in the calmer air outside the column of moving air, plus in the air behind the ball. These forces keep the ball from moving too far to the left or right – or even upwards. Adding the tube from above channels the moving air into the narrower space. This makes the air gain speed – and lose pressure – causing the ball to follow it upwards.

TAKE CARE!

Because it uses an electrical appliance, this experiment should be carried out by a responsible person. Remember, it's the movement of the air – and not the heat – that makes the experiment work, so use the coolest setting on the hairdryer.

VIKING FUNERAL

Viking warriors who died in battle would be sent to Valhalla in style, or at least that's how Hollywood has always imagined their culture. A longboat would be set ablaze and sent off to the open sea on its way to Valhalla. You can add a little Viking ornamentation to the basic structure of the boat in this experiment to book your own meeting with Odin, but the demonstration appeals to the child in all of us no matter how it's presented. The experiment could be done in a bath but ideally – and to benefit from the whole 'Viking funeral' angle – it should be performed on the calm waters of a small pond.

YOU WILL NEED

- Aluminium tube for tablets or pills (about 10 cm long, with a screw top)
- 4 small candles
- Matches
- An empty shallow tin (e.g. for sardines or pilchards) just large enough to hold the tube lengthways
- Drill or nail to puncture the screw top of the tube

METHOD

1. Using a drill or nail, make a small hole (from the inside out) in the screw top of the aluminium tube. The hole should be just off-centre so that steam will be able to escape from it later.

2. Half-fill the tube with water and screw the top back on.

3. Place the candles in the tin, in a line against one of the long edges. You can secure them in position with a little wax dripped into the tin.

4. Place the tube (with the hole on top) inside the tin against the other long edge, and secure it in the same way. The candles and tube should all fit quite snugly.

5. Light the candles and place the tin on the surface of the water.

6. The 'Viking longship' soon begins to travel under its own head of steam.

THE SCIENTIFIC EXCUSE

The candles alongside the tube heat the water inside. This water soon reaches boiling point and the steam needs to find an escape point: the small hole. The steam expands quickly and creates a noticeable recoil as it leaves the narrow opening.

TAKE CARE!

On a practical level, note that the vessel is quite fragile so it's best to wait for calm weather – and water conditions – before conducting the experiment outside.

MATCH ALERT!

This experiment involves the use of matches and should be conducted only by a responsible adult.

THE BOLD LITTLE BALL

This experiment is a little gem. It has just two ingredients and can be performed in a matter of seconds. But irresponsible? Well, it's not messy, or loud or likely to give anyone an electric shock. But it could become dangerous if you dare someone else to blow the ball from the funnel. Then you might need to take cover from your purple-faced – and very frustrated – friend!

YOU WILL NEED

- Narrow-mouthed funnel (a cooking funnel is ideal)
- One table-tennis ball

METHOD

1. Put the ball into the funnel and hold upright.

2. Tilt your head back and put the mouth of the funnel to your lips.

3. Blow.

4. While blowing, slowly tilt the funnel so that it should 'pour out' the ball – yet it doesn't!

THE SCIENTIFIC EXCUSE

Here is where things get even better. The ball stays in place because of the Bernoulli Effect – the same scientific reason that a jumbo jet stays airborne. Basically, the Bernoulli Effect describes how moving air (in this case, the air rushing into the funnel and along its sides) has lower pressure than air that's still. A light object, such as a feather or the ball in this experiment, will move to the area of lower pressure: the air behind the ball – even when the funnel is pointing down – has higher pressure and keeps the ball in place.

TAKE CARE!

Luckily, there's no direct risk associated with this experiment. If you choose to dare people to try it – or even make a bet – then you might face some angry reactions ...

– THE –
UNPOPPABLE BALLOON

Here's another one of those experiments that's so startling, so counter-intuitive, that you should really perform it as a magic trick. After all, how often have you seen – much less been able to perform yourself – a demonstration as baffling as this one? And if that weren't enough of a billing, it's really easy to do.

YOU WILL NEED

- Balloon
- 30-cm cooking skewer
- Cooking oil

METHOD

1. Inflate the balloon, but not quite fully. Tie the open end as you would normally.

2. Brush the skewer on both sides with cooking oil.

3. Hold the skewer with one hand and the balloon in the other (making sure that the knot of the balloon is on the balloon's 'equator' rather than on one of the 'poles'). If you're doing it as a trick, you could have an assistant hold the balloon.

4. Slowly pierce the balloon with the skewer, twisting slowly and taking care to enter at the knot and to exit exactly opposite (where there should still be a small amount of slack).

5. Equally carefully, remove the skewer; hold the balloon by pinching the far hole. The balloon will still not burst although you will notice it slowly losing air.

6. Puncture the balloon deliberately by quickly piercing the stretched side of the balloon.

THE SCIENTIFIC EXCUSE

The rubber of the balloon consists of many interlinked long molecules, which are known as polymers. The molecules are held together in a pattern called cross-linking, which allows for some elasticity. If there's still some slack in the cross-linking (as there is in the knotted end and its opposite extreme), the polymers can 'close ranks' around a small incision. The rubber actually forms a seal around the skewer that has just pierced it. Lubricating the skewer makes this entrance a little easier, and it helps provide a temporary patch when the skewer is removed. At the end of the experiment, you can burst the balloon easily by puncturing the stretched side, which hasn't enough slack to form a protective seal.

TAKE CARE!

Make sure an adult wields the skewer. If you do decide to perform this as a magic trick, don't let your audience see you perform step 2. Also, make sure you pop the balloon soon after the 'payoff' – before people notice that the balloon is slowly deflating anyway.

– THE –

TEABAG BALLOON

There's something magical about taking an everyday object and getting it to behave in a particularly unpredictable way. In this case the object is a humble teabag, which can be carefully taken apart and then set alight. The teabag will float upwards, as if by magic. Because even a slight puff of wind could disrupt this delicate experiment, it's best done inside – or outside in very sheltered surroundings on a calm day.

· YOU WILL NEED ·

- Teabag (the sort with a string and tag)
- Matches
- Small plate
- Staple remover (or strong fingernails)

METHOD

1. Remove the string and tag from the teabag.

2. Using a staple remover or your fingernails, remove the staple from the teabag.

3. Unfold the teabag and pour the loose tea out of it.

4. Stand the emptied teabag – which is now shaped like a cylinder – on its end, on a small plate.

5. Light a match and set fire to the top of the teabag.

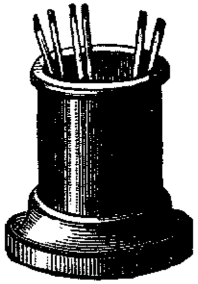
6. As the flame burns down, the burning teabag will shake a little and then float up into the air.

— THE SCIENTIFIC EXCUSE —

It's the old chestnut – 'hot air rises' – at work here. The fire causes two things to happen. One is that the air around the teabag gets hotter and hotter. Another is that – because of the burning – the teabag loses weight (or mass, if you want to be really scientific). These two factors converge, eventually reaching a point where the air is warm enough – and the teabag light enough – to produce lift-off.

— MATCH ALERT! —

This experiment involves the use of matches and should be conducted only by a responsible adult.

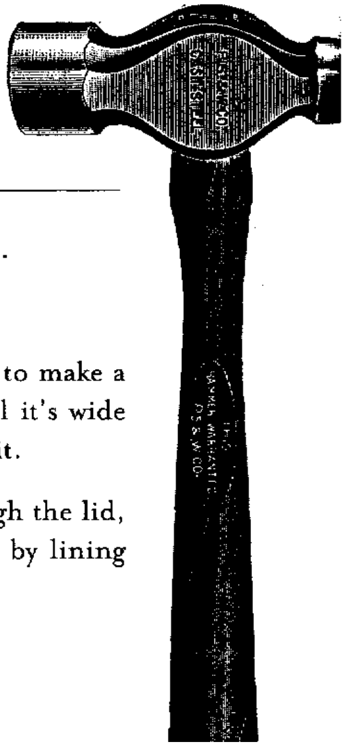


THE LAST STRAW!

Some of the best science experiments are the ones that overturn our preconceptions, prompting calls of: 'That's not right – it can't be.' This experiment is a fine example of one of those myth-busters, bound to get someone hot under the collar. Getting a drinking straw to work is child's play, isn't it? Well, find me a child because this one's not working!

YOU WILL NEED

- Clean glass or plastic jar with a tightly fitting lid
- Drinking straw (plastic or paper, but plastic works better)
- Water
- Plasticine
- Hammer and nail or awl



METHOD

1. Fill the jar about 2/3 full of water.

2. Fix the lid on tightly.

3. Use the hammer and nail or awl to make a hole in the lid; work the hole until it's wide enough for the straw to fit through it.

4. Slide the straw downwards through the lid, judging how far down it should go by lining the lid up against the jar.

5. Seal the edge of the hole around the straw with some Plasticine, working it in so there's no gap at all.

6. Screw the lid back on the jar and try to drink through the straw. You – or your disgruntled volunteer – should find it impossible.

THE SCIENTIFIC EXCUSE

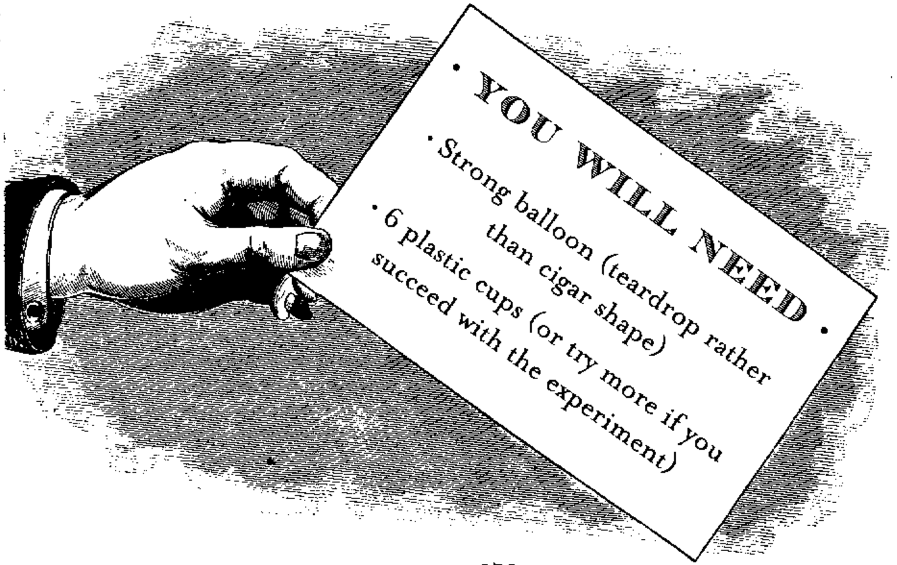
The preconception mentioned already is that we suck water directly when we drink through a straw. This experiment shows that it's all about air and air pressure. The air around us exerts pressure on everything it touches, including the surface of a drink in a glass or open jar. When you put a straw in a drink normally (that is, when the drink is in an uncovered container), the pressure of the air on the drink is the same as the pressure of the air coming through the straw. But when you suck on the straw, you remove some of the air and reduce the pressure in the air that's left in the straw. The air pressing down on the surface of the drink, however, still has the same pressure. The difference in pressure pushes the liquid into – and through – the straw. Sealing the lid tightly blocks the outside air from pressing down on the liquid in the jar, so now matter how much you suck, there's no pressure from inside to force the liquid into the straw.

TAKE CARE!

There's no danger involved with this experiment, but it's worth noting that plastic straws can be reused more often than paper ones since they are that much stronger.

BALLOON POWER

We often lose sight of the fact that air has mass and exerts pressure. Sure, we all register when the Met Office talks about air pressure, but that's a little abstract. This experiment brings it all home, though, and is something of a work in progress. Some children have managed to attach more than two dozen cups to their balloons – see how (and why that amount is so impressive) by reading on.



• YOU WILL NEED •

- Strong balloon (teardrop rather than cigar shape)
- 6 plastic cups (or try more if you succeed with the experiment)

METHOD

1. Blow up the balloon until it's about the size of a grapefruit. Pinch it shut temporarily.

2. Wet the rims of two plastic cups.

3. Press the cups to the sides of the balloon and continue to inflate it. The cups should remain fixed to the balloon.

4. Try repeating the process – pinch, wet, press and inflate – seeing how many balloons you can attach.

THE SCIENTIFIC EXCUSE

As mentioned in the introduction, this experiment is all about air pressure and its counterpart, suction. Wetting the rims of the cups allows them to stick on initially because of water tension. But by inflating the balloon – and reducing the curvature of balloon coming in contact with the cups – the air pressure inside the cups reduces somewhat because the same amount of air now fills more space. The air pressure outside the cups, however, remains the same. This difference of pressure causes the cups to be pushed into the balloon.

TAKE CARE!

Some people obviously have a knack for succeeding with this experiment, but even the least experienced experimenter should be able to get at least two cups to stick. Make sure you keep a little pressure on each cup just after attaching it, so that it will 'take'.

THE RED SQUARE EXPRESS

It came as something of a surprise to the wider world to learn that one May evening in 1987, a private aircraft from Germany lazily circled central Moscow, buzzed Lenin's tomb and taxied to a halt by the Kremlin walls. What made the story even more unlikely was the fact that the pilot, Mathias Rust from West Germany, was only 19 years old.

It is true that the Soviet Union in 1987 was a less menacing place than it had been during the dark decades of Stalin's rule. Led by a young and vigorous leader, Mikhail Gorbachev, the country was slowly ridding itself of the worst excesses of communism. People were freer than they had been for decades to express themselves, and even to offer some mild criticism of the government.

On the other hand, the Soviet Union still prided itself on its might and weaponry. Each May Day saw ranks of Soviet troops and weapons parade through Red Square – the very spot that Rust chose as a landing runway. And the Soviets were not shy about defending their territory from intrusion: in 1983, Soviet fighters had shot down Korean Airlines flight 007, which had strayed into Soviet airspace. All 269 people on board had been killed.

Rust had succeeded by sticking to a simple plan. He had flown his single-engine Cessna out of Helsinki, telling controllers that he was going to Stockholm. Then he turned east, switched off radio communication and carried on across 700 km of the most fiercely-defended airspace on Earth. He passed through various zones of Soviet air defence, either by flying too low for radar detection or because his plane was confused with Soviet training aircraft. Some reports even suggest that he landed along the way, throwing pursuers off the trail.

A small group of bewildered pedestrians surrounded Rust's plane when he did come to a halt by the Kremlin. Soon afterwards, he was arrested. Rust went on trial in September 1987 and was sentenced to four years in a labour camp. He served just over a year, and was released on parole before being sent back to West Germany. His idea had been to promote peace through his flight. In the end, he was simply relieved that he hadn't caused a Third World War.

DON'T PRESSURE ME

Some of the most astounding scientific displays can be performed with a minimum of fuss and special equipment. This counter-top performance demonstrates one of the most important unseen forces around us – air pressure. It might be invisible, but it certainly does its bit to make it hard to p-u--, p-u-u-u-l, *pull* this dratted carrier bag out.

YOU WILL NEED

- Metal or stout ceramic mixing bowl (25–30 cm diameter)
- Strong elastic band (the sort used by postmen should do fine)
- Plastic carrier bag (check that there are no ventilation holes)

METHOD

1. Line the inside of the bowl with the carrier bag, feeding any surplus up and around the rim.

2. Secure the plastic overlap to the bowl with the elastic band.

3. Put the bowl-bag combination on a table or counter and ask a friend to pull the bag out of the bowl by holding it at its centre.

4. Your friend will find it very hard – and maybe impossible – to make the bag budge.

THE SCIENTIFIC EXCUSE

To understand this experiment, you must think a bit about air pressure. By securing the bag to the outside of the bowl, you have trapped some air between the outside of the bag and the inside of the bowl. By pulling up on the bag you are trying to increase the space (volume), and that is when Boyle's Law comes into play. If the volume of gas (in this case, air) in a closed system increases, its pressure decreases. That is exactly what is happening inside the bowl and under the bag. The air pressure *outside* the plastic bag, however, retains its strength – forcing the air hard against any increase in volume.

The German scientist Otto von Guericke took this demonstration even further in 1650, by sucking all of the air from a globe created from two joined copper hemispheres. With no air pressure to help them from inside the globe, teams of horses connected to each half failed to pull the hemispheres apart.

TAKE CARE!

Make sure that you line the inside of the bowl as much as possible in order to help create the largest possible air pressure difference. Try to get the best match that you can between the sizes of the bag and the bowl.

-THE- SLIDING TUMBLER

Or should that be the tumbling slider? No – that will have to wait for another volume, like 'The Tale of the Giant Rat of Sumatra' (which Sherlock Holmes never got round to telling Dr Watson). At any rate there's no real need to look any further, because this little gem provides that subtle hint of magic that turns experiments into lasting memories. Try it a few times – you'll certainly warm to it.

YOU WILL NEED

- Plastic-coated tray
- Glass tumbler
- Candle
- Matches
- Water
- Several small paperback books

METHOD

1. Slide a book under a narrow end of the tray.
2. Wet the rim of the tumbler and put it upside down on the tray near the top.
3. The tumbler will stay where you set it down.
4. Take a lighted candle and put it close to, but not touching, one side of the tumbler.
5. The tumbler will start to slide slowly down the slope of the tray.

THE SCIENTIFIC EXCUSE

The water round the rim makes an air seal inside the tumbler. Then the candle warms the air inside, causing it to expand. The expanding air pushes the tumbler slightly up, so that it now 'floats' over the tray with just a seal of water to help it slide. The rest is there to be seen.

TAKE CARE!

It's worth trying this experiment out a few times on your own to work out exactly how many paperbacks produce a decent slope – but not so steep that the tumbler slides down without help from the candle.

MATCH ALERT!

This experiment involves the use of matches and should be conducted only by a responsible adult.

PING-PONG PUMP

You're in the middle of a tough ping-pong game with your best friend. The winner will have bragging rights for the next year. It's tough – the lead, like the game itself, is going back and forth. Forehand, backhand return, backhand, lob … smash! The ball nicks the table for a winner and you've got match point – except your opponent picks up the ball. He shows you a dent where it caught the edge of the table: 'Too bad. That's our last ball. Looks like we'll have to settle this another time.' He's probably right. Your moment of glory will have to wait.

Or will it?

YOU WILL NEED

- A dented table-tennis ball (see note below about dents and cracks)
- Hot water (the hottest from the tap should do)
- Small mixing bowl or jam jar
- Empty plastic drinks bottle (with lid off)

METHOD

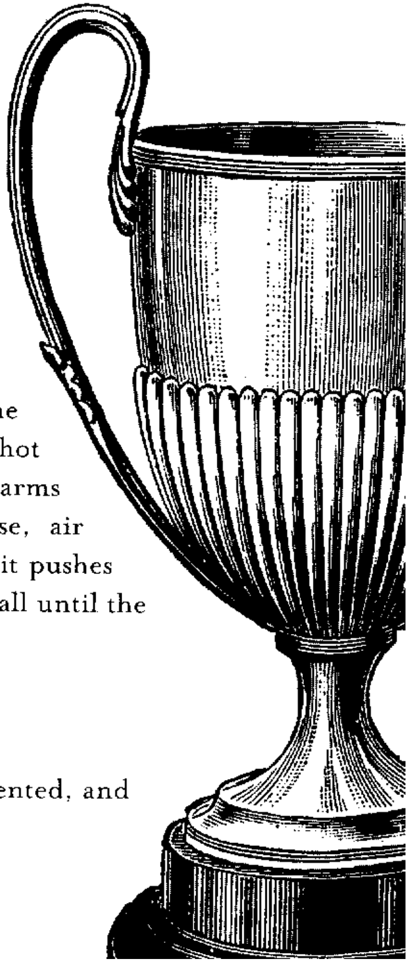
1. Fill the bowl or jar two-thirds full with hot water.

2. Drop the ball into the water.

3. Hold the drinks bottle upside down with the opening just touching the floating ball.

4. Carefully push the bottle down so the ball goes underwater.

5. Keep the bottle and ball in place until the dent pops out (this usually takes less than a minute).



THE SCIENTIFIC EXCUSE

You've saved the day – and your chance to win the match – with some basic science. The water is not hot enough to damage the ball but it warms the air inside it. And, of course, air expands as it warms. In this case, it pushes outward against the inside of the ball until the outside pops back into shape.

TAKE CARE!

This only works on balls that are dented, and not pierced or cracked.

— THE —
HANKIE DAM

Admit it – dumping a glass of cold water over someone's head is funny. In fact, without glasses of water and custard pies, the world would have been robbed of some classic slapstick routines. But how funny is it for the person under the glass? And would you be willing to try it over the head of, say, your elderly aunt? Read on to see how you might manage this stunt – and survive.

YOU WILL NEED:

- Drinking glass
- Water
- Handkerchief
- Elderly aunt (optional)

METHOD

1. Fill the glass with water.

2. Spread the handkerchief over the top of the glass, holding it tightly in place.

3. Find an aunt or anyone else prepared to take part.

4. Still holding the handkerchief in place, flip the glass and hold it upside down over the person's head.

5. The water won't spill.

THE SCIENTIFIC EXCUSE

Two forces are at work here – air pressure and surface tension. The air is pressing up on the fabric of the handkerchief. This fabric, however, has become saturated with water and therefore has strong surface tension. The air is pushing up but meeting a barrier in the form of surface tension. Provided the glass is held exactly upside down, the air pressing up and the water pressing down are kept apart because of the surface tension. But if you hold the glass at an angle, or let some slack into the hankie, more water can press down in places – and air can press up in others. That can mean only one thing: a spill.

TAKE CARE!

Just to be on the safe side – and to help you gain confidence – you can practise this a few times over a sink or basin.

BOTTLING OUT

This experiment works best if you perform it as a sort of competition. The challenge is simple: who will be the first to blow up a balloon inside a bottle? Find one of your most competitive friends and lay down the challenge. But to make sure you come out on top, complete steps 1 to 4 before you invite your friend to compete.

• YOU WILL NEED •

- 2 balloons
- 2 empty plastic fizzy drinks bottles (1.5 litre capacity)
- Sharp knife or scissors
- Volunteer

METHOD

1. Cut a 1 cm hole in the bottom of one bottle.
2. Stretch a balloon across the mouth of each bottle.
3. Use your little finger to push each balloon gently inside its bottle (keeping it attached to the mouth).
4. You should now have a balloon hanging loosely inside each bottle but still attached to the top.
5. Ask your friend to race you to see who can blow up a balloon fastest. (Hand your friend the bottle with no hole in it, and make sure they don't see the hole in yours.)
6. Blow up the balloons.
7. Yours – inside the bottle with the hole – should blow up pretty easily. Your friend, though, will be turning all sorts of colours and failing to get anywhere!

THE SCIENTIFIC EXCUSE

Like so many of the best experiments, especially the ones that leave people steaming, this has a simple explanation. When you blow up a balloon, it expands to make room for this extra air. It does this by pushing aside the air molecules that surround it. The air molecules in the 'holed-out' bottle get pushed out of the hole, which amounts to the same thing. The air molecules in the other bottle, though, have nowhere to go, so there's no room for the balloon to grow.

TAKE CARE!

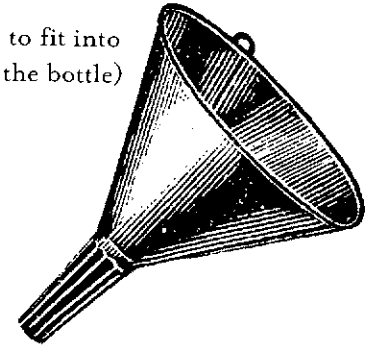
An adult should cut the hole in the drinks bottle, because the plastic is strong and you need an equally strong, steady hand to cut through it.

AIR BLOCK!

Here's a chance to mix sleight of hand with science – and in the process, a chance to impress people and maybe even win a bet. What's at stake, apart from anything you might wager with a sceptical friend, is whether you can fill the bottle with water. It's nearly there to begin with, so it shouldn't be hard. 'You sir, I bet you can't manage it – and that I can.'

YOU WILL NEED

- 1-litre bottle (glass or plastic)
- Funnel (with a spout narrow enough to fit into the bottle)
- Plastic jug
- Modelling clay
- Water
- Small pin
- Volunteer
- Witnesses



METHOD

1. Fill the bottle two-thirds of the way up with water.

2. Feed the funnel into the opening of the bottle. There should be a good 5–8 cm between the bottom of the funnel spout and the water level inside the bottle.

3. Secure the funnel tightly in place with modelling clay.

4. Fill the plastic jug with water and ask your victim to fill the bottle using that water.

5. The funnel should fill up easily enough, but your friend will find it impossible to get any of the water from there into the bottle.

6. Here's the tricky bit: distract your friend and the witnesses for a split second and stick the pin into the clay (so it goes between the spout and the funnel inside the bottle).

7. Slowly pour some more water in with a flourish, and while people are watching your pouring hand, pull out the pin.

8. The water should pour right in.

THE SCIENTIFIC EXCUSE

It doesn't look as though anything is inside that bottle above the water, but in fact there is something that's pretty strong – air. That air has filled the space, and with no way for it to escape (you've seen to that with the clay), it will stop any water from entering. The pin prick allows air to escape and water to flow in.

TAKE CARE!

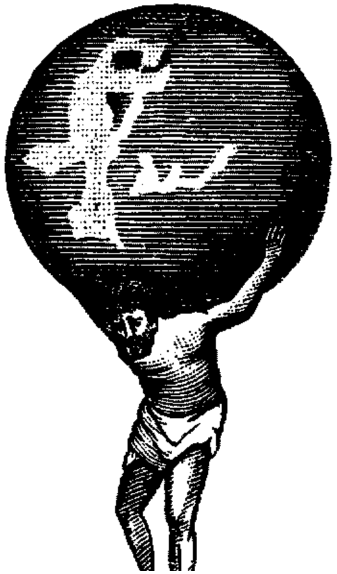
The pin, of course, is the secret weapon. Have it hidden somewhere – maybe stick it on your belt loop so you can pull it out easily when everyone else is distracted. Use a pin with a head large enough to be felt once you've stuck it in: you don't want to have to search for it.

WEIGHT OF THE WORLD

Air, like water or ice-cream or mud, has both mass and weight. In other words, it can be weighed just like those other substances. The total mass of the air surrounding us – what the scale would read if you weighed it – is 5,140,000,000,000,000,000 kg. And if your friends find it hard to believe that air could weigh *any*thing, try out this experiment on them.

YOU WILL NEED

- 2 balloons
- String
- Scissors
- 1 m rule
- Sticky tape
- Pin



METHOD

1. Cut off two strips of sticky tape, each exactly 2 cm long; keep these handy.
2. Cut two 40-cm lengths of string.
3. Blow up both balloons until they are exactly the same size and tie them off.
4. Tie one end of each length of string to the balloon knots.
5. Use the saved sticky tape to attach the other end of the strings to the measuring stick – one at each end.
6. Hold one arm outstretched and balance the stick (with balloons at each end) on an outstretched finger.
7. Now pop one of the balloons with the pin.
8. The other balloon will drop and the stick will fall off.

THE SCIENTIFIC EXCUSE

Blowing up the balloons fills them with air – we all know that. But it also means that the inflated balloon weighs more because of this extra air that has squeezed in. Popping a balloon allows the air to escape, and the balloon loses the extra weight.

TAKE CARE!

The risks to you? Well, there are two. The first is seeming like too much of a know-it-all before you get going (so maybe you'd better go easy with that 'kg total' figure). The second is seeming like too much of a know-it-all after you've done this simple demonstration. Wipe that smirk off your face – now!

BALLOON HANG TEN

This daring experiment has come to us all the way from Australia. Maybe after you've mastered it, you'll see why the Aussies are among the world's best surfers. From Fremantle to Bondi Beach, those daring denizens of Down Under have proved their skills balancing on surfboards in the biggest of waves. Is it possible that they practise in their sitting rooms in the off-season? See what you think after you've had some practice yourself.

• YOU WILL NEED •

- Piece of stout plywood (about 60 cm square)
- Balloons (you'll need four, but have some spares)
- Carpeted floor
- Volunteer

METHOD

1. Half-fill four balloons and tie them off.

2. Put the four balloons under the piece of plywood on the floor.

3. Have your volunteer hold the plywood steady as you step onto it.

4. Wait for one of the balloons to pop – none of them should!

THE SCIENTIFIC EXCUSE

This is one of those experiments that recalls the elephant's footprint: it's shallow because the wide foot spreads the weight and lessens the pressure at any one point. The same holds true here. When you stand on the wood, your weight exerts downward pressure. But the balloons are only half full, so they can flatten and widen out – increasing the exposed area and reducing the force. Surprisingly, they reach a sort of balance point at which they've flattened enough to support your weight – and maybe even have room for more.

TAKE CARE!

Don't underestimate the surfing angle here: it really is easy to lose your balance when you're on such a set-up. Keep your arms outstretched – like a tightrope walker – to help you keep upright. And it might be sensible to remove breakables from the experiment zone.

HEAVY READING

Your father is the sort who gets everything just so – cushions plumped, reading lamp positioned, footstool in place – before he settles down to read his Sunday paper. So will he take kindly to seeing that today's edition begins on page 3? How much happier will he be to see you spreading the paper on the table and attacking it with a ruler? It looks as though you've got some explaining to do. Over to you, professor.

YOU WILL NEED

- A full sheet of newspaper (that is, numbered pages such as pages 1 and 2, and the last two pages)
- Wooden ruler
- Level table or large counter

METHOD

1. Spread the newspaper sheet flat (with the fold pointing down) on the table or counter.

2. Make sure the paper is more or less flush with the edge of the table or counter.

3. Slide the ruler under the paper until only about 10 cm of it still sticks out from the table.

4. Slap your hand down on this extended bit of ruler.

5. Instead of being launched into space, the paper will stay pretty firmly in place.

THE SCIENTIFIC EXCUSE

Scientists use the word 'counter-intuitive' to describe events that seem to contradict our expectations. And we would certainly expect to be able to send that light piece of paper into orbit. But this experiment demonstrates how we'd be ignoring something very important – air pressure. The force of the air pushing down over a fairly large area – all of the newspaper sheet – is greater than the force of the ruler pushing up.

TAKE CARE!

This experiment works best with the largest newspaper sheet possible. What you really want is part of a broadsheet newspaper (like the *Sunday Times* in the UK or the *Sydney Morning Herald* in Australia), rather than a smaller tabloid newspaper.

STRAW ROCKET

That means drinking straw, and not 'scarecrow' straw, by the way. But even a drinking straw rocket might seem a little far-fetched unless you can figure out how to harness Newtonian physics. After all, if Sir Isaac could start to theorise about gravity after being hit by an apple, just think what he might have come up with had he had plastic straws at his disposal.

Hint: you might find it easier to locate straws by popping into a nearby branch of a famous burger chain or high-street coffee chain. Of course, you'll want to buy something to keep your conscience clear.

YOU WILL NEED

- 2 plastic drinking straws (note: they must have different diameters)
- 200 ml squeezable fruit drinks bottle (such as Robinsons Fruit Shoot bottle)
- Modelling clay
- Small piece of cotton wool

METHOD

1. Make sure the drinks bottle has been rinsed thoroughly and has dripped dry.

2. Feed the narrower straw into the opening of the drink bottle and plug any gaps with modelling clay.

3. Plunge one end of the wider straw into some more modelling clay to make a plug. Trim any excess (while making sure it still works as a plug).

4. Stick a small wad of cotton wool over the outside of the clay plug. This will make the end of the rocket less dangerous when it is launched.

5. Slide the wider straw down over the narrower one. Let it rest gently (do not jam it in) and hold the bottle upright so that the straw points upwards.

6. Have your friends perform the countdown, and when they reach 'zero' squeeze the bottle hard.

7. The outer straw will be launched into space.

THE SCIENTIFIC EXCUSE

We did say Newtonian physics was at work here – his Third Law of Motion to be precise (that for every action there is an opposite and equal reaction). The action is the air being forced through the smaller straw. It hits the plug at the end of the wider straw and triggers the reaction – focusing on the small plug so that the force is channelled into launching the straw rocket.

TAKE CARE!

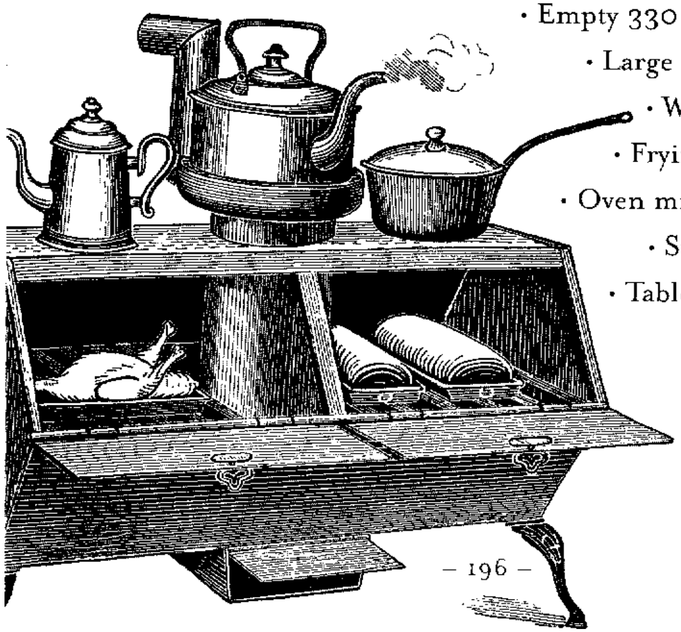
Make sure you point the rocket upwards, and not at anyone near you. Even a flying straw can cause an injury.

THE CAN CAN-CAN

There's a wonderful scene in the film *Jaws*, where the tough shark-hunter Quint finishes his beer and crushes the can in his bare hand. You can perform a variation of this feat – with even more drama – by demonstrating some of the wonderful powers of water. You might not get the shark, but you'll impress some of the nearest landlubbers.

YOU WILL NEED

- Empty 330 ml drinks can
- Large saucepan
- Water
- Frying pan
- Oven mitt or tongs
- Stove
- Tablespoon



METHOD

1. Heat the frying pan on the stove until it is hot enough to use for cooking.

2. Meanwhile, fill the saucepan to a depth of about 3–4 cm with cold water.

3. Carefully pour a tablespoon (15 ml) of water into the can.

4. Use the mitt or tongs to place the can on the frying pan.

5. Leave the can there for about 10 seconds and then use the mitts or tongs to transfer it to the saucepan.

6. Place the can in the saucepan upside down.

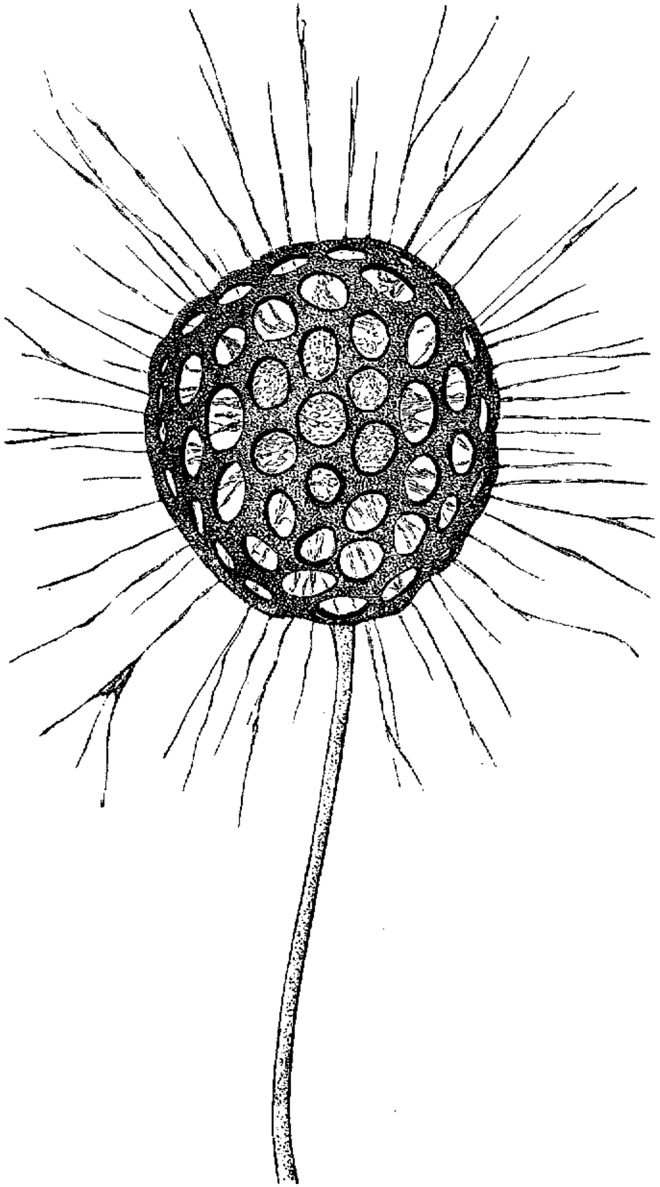
7. The can should collapse rapidly with a loud crunch.

THE SCIENTIFIC EXCUSE

Lots of interesting experiments demonstrate how air expands when it is heated up. This experiment gives that a little twist by heating up the small amount of water in the tin until it boils. The tablespoon of water turns into water vapour, a gas that drives the air out of the tin. By plunging the tin into the cold water, the temperature plummets and the vapour turns back to liquid water (in a process called condensation). But turning back to liquid means that the water takes up far less space ... and as all of the air was driven out earlier, there's nothing to stop the pressure of the saucepan water pushing in on it.

TAKE CARE!

Because of the stove, hot pan and boiling water, this experiment must be carried out by an adult.



100%

NATURAL

Mother Nature is conducting all sorts of experiments – irresponsible or otherwise – all around us, all of the time. The following chapter takes the lid off some of her secrets and leaves the lid firmly shut on those that need darkness and time in order to work out. Flex your scientific muscles a little and then try your hand at directing plants, creating blubber or turning brittle bones to rubber. How can you do all this? Just act 'naturally' and read on.

POND-LIFE PALS

Bringing smelly, slimy water weeds into the freshly cleaned kitchen? Erm, it's 'all in the cause of science': this experiment helps us learn that plants really are the 'lungs' of the world around us.

YOU WILL NEED

- 3–4 shoots of waterweed (e.g. Canadian pondweed, curly waterweed) from a garden pond
- 3 clothes pegs
- 750 ml–1 litre wide-mouthed glass jar
- 7–8 cm test tube
- Small funnel (to fit easily within jar)
- Matches
- Water

METHOD

1. Fill the jar with fresh water and add the waterweed.

2. Make sure that your waterweed specimens are still alive by checking to see that they emit bubbles.

3. Clip the clothes pegs to the wide rim of the funnel to form a tripod.

4. Lower the funnel-tripod down so that most of the shoots are inside the cone. Make sure the narrow end of the funnel is higher than the water level.

5. Place the test tube over this end of the funnel.

6. Wait for 2 hours and then remove the test tube carefully, keeping it upside down.

7. Have someone light a match and then blow it out.

8. With the match-head still glowing, place it inside the test tube. It should ignite.

THE SCIENTIFIC EXCUSE

The bubbles coming up from the plants (and trapped by the test tube) are oxygen, a by-product of the food-producing process called photosynthesis. After an hour or two, enough oxygen has been collected to provide the fuel for the combustion of the glowing match.

TAKE CARE!

Make sure that you haven't killed your oxygen-producers on the way from the garden pond (see step 2). Be patient so that enough oxygen builds up. Be careful when handling matches but at the same time remember that the match-head still needs to be glowing somewhat if the oxygen is to do its party piece.

MATCH ALERT!

This experiment involves the use of matches and should be conducted only by a responsible adult.

– THE – RUBBER CHICKEN BONE

Politicians sometimes complain – particularly around election time – of spending too much of their lives on the 'rubber chicken circuit'. We all know what they mean: endless meals with boring speakers while they chew and chew and chew their way through tasteless chicken. But perhaps there's a scientific reason for all this, and maybe it's not simply a cliché? Try this experiment and see.

YOU WILL NEED

- Good-sized thigh or drumstick chicken bone, left over after a meal
- Jar big enough to hold the bone with some room to spare (preferably with lid)
- Vinegar

METHOD

1. Clean the bone thoroughly.
2. Rinse it off under running water.

3. Put the bone in the jar and cover with vinegar.
4. Fasten the lid or other covering on the jar.
5. Let the jar sit for about three days.
6. Carefully remove the bone and rinse under running water again.
7. Examine the bone and see how it feels.

THE SCIENTIFIC EXCUSE

We can all remember the advice to drink lots of milk and eat dairy products when we were young because they contained calcium to help build our bones. In fact calcium doesn't just build the bones: it keeps them rigid. And it does the same with chicken bones. Vinegar is a mild acid, but still strong enough (given time) to dissolve the calcium (which is a base) in the chicken bone. After a few days, it's done its job and you've got your real-life rubber chicken!

TAKE CARE!

This experiment is safe and you run a risk only if you spill the vinegar–chicken bone mixture. Make sure it's nowhere near carpets or expensive furniture.

THE NON-DRIP DOCUMENT

'Less is more', as the great modernist architect Mies van der Rohe would say, and this simple experiment certainly lives up to the adage. It takes just over a minute to perform, but it gives a lovely demonstration of some basic science. And what's more, the main ingredient – the piece of paper – can become the star attraction. Try using something that looks really important, something that looks as though it would be ruined if even a drop of water got onto it. That should make the wait in the last stage the longest minute your audience will have endured.

YOU • WILL • NEED

- Clear drinking glass
- Water
- Sink or large 3–4-litre pot
- A4-sized piece of paper (could be newspaper or, ideally, something that looks important or 'business-like')

METHOD

1. Fill the sink or pot nearly full of water.

2. Loosely crumple the piece of paper.

3. Shove the crumpled paper into the bottom of the empty glass, tight enough so that it won't fall out when the glass is overturned.

4. Plunge the glass upside down into the water, deep enough that the paper appears to be under water.

5. Keep the glass in that position for a minute.

6. Take the glass out of the water and retrieve the paper; dramatically straighten it and hand it round. It will be dry.

THE SCIENTIFIC EXCUSE

The air inside the glass has protected the paper from the water by acting as a barrier. This air is lighter than the water, so it can't flow down through the rim of the glass. At the same time, the water can't flow into the glass because the glass is already full – of air!

TAKE CARE!

This experiment is a revelation even if you use a discarded page from a newspaper that would otherwise be recycled. If you do raise the stakes, make sure you use a piece of paper that seems to be valuable (a photocopy of an invitation or school letter, for example). You don't want to run the risk of having the real thing fall out because you hadn't shoved it in hard enough.

INTRODUCTION TO ALCHEMY

All right, we can't pretend to teach you how to find the Philosopher's Stone, but this experiment does touch on one of the main aims of those medieval alchemists – changing the nature of metals. Of course, they were looking for a way of turning base metals such as lead into gold, but here you'll have a chance to turn iron into copper. Or at least that's what you'll seem to have done.

◆

— YOU WILL NEED —

- 12 x 1p or 2p coins (dull ones work better)
- Spoon
- One ungalvanised iron nail
- Ceramic or plastic bowl
- 150 ml vinegar
- 1 tsp salt
- Paper towel

METHOD

1. Add the vinegar to the bowl and stir in the salt.

2. Place the dull coins in the bowl (adding a little more vinegar if they aren't fully submerged).

3. Leave the coins in the bowl for 5 minutes.

4. Retrieve the coins from the bowl using the spoon and let them dry on the paper towel (do not dump out the vinegar/salt mixture).

5. Add the nail to the bowl of liquid and keep it there for 30 minutes. Observe the tiny bubbles forming around it.

6. Carefully take the nail out of the bowl and set it on paper towel to dry. It should appear to be copper!

— THE SCIENTIFIC EXCUSE —

In the first stage of the experiment, the vinegar solution 'cleaned' some of the copper off the coins. This copper remained in solution (with the vinegar and salt), which in turn had a chemical reaction with the iron on the surface of the nail. As part of this reaction, a chemical exchange left a copper coating on the nail. This type of chemical addition of a metallic layer is called plating; you have created a copper-plated nail. Next stop gold!

TAKE CARE!

This experiment works best if the concentration of copper (from the coins) is relatively high – so make sure you don't overdo the amount of vinegar you use. Don't choose too big a bowl, since the amount of liquid needed to cover the coins would weaken the solution.

A GOOD HEAD FOR LIGHTS

The pun in this title might make you groan, but the nifty experiment below has all the hallmarks of a classic demonstration: it's quick, easy and scores high on the 'ooooh' scale. And what's more, there's some really interesting science at its heart. For best results perform the experiment after dark, so the effect will appear that much spookier.

YOU WILL NEED

- Balloon
- Fluorescent (strip) light bulb
- Volunteer with a good head of hair
- Second volunteer to hold the bulb

METHOD

1. Inflate the balloon and tie it shut.

2. Have one volunteer hold the bulb carefully, with the metal contact pointing outwards.

3. The person with the balloon should rub it vigorously against his or her head for 10 seconds and then touch the metal contact of the fluorescent bulb.

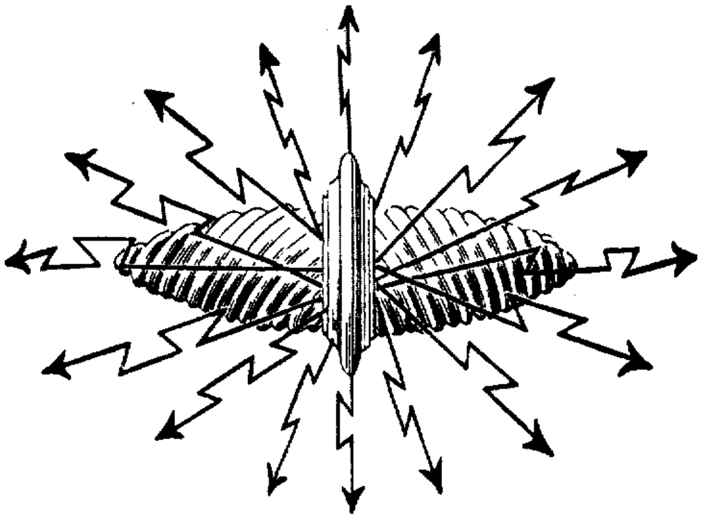
4. The bulb should give off a ghostly glow.

THE SCIENTIFIC EXCUSE

The gas inside a fluorescent light bulb becomes 'excited' when even a small amount of electricity flows through it. Rubbing the balloon against hair creates static electricity, so when the balloon touches the metal contact, electrons flow into the bulb. This modest electrical charge excites the low-pressure gas inside, which in turn excites the phosphorous coating of the inside of the bulb. That last stage produces visible white light.

TAKE CARE!

Make sure that the volunteer handling the fluorescent bulb is careful and responsible.



THE LARGEST SAND TRAP

It has been noted many times that people can become obsessive about golf. Is it because for just one putt – or maybe even for an entire hole – a hacker can feel like the equal of Tiger Woods or Jack Nicklaus? Or maybe because striding around an 18-hole course gives stressed-out executives their only chance to get away from it all, if only for a few hours?

Hollywood star Samuel L. Jackson insists on time off for rounds of golf when he negotiates film contracts. *GolfPunk* website and magazine caters to a new generation of golfers who prefer street fashion and crazed antics to blazers and club dinners. Some golfers have taken to the streets – literally – to enjoy rounds of urban golf, with bins taking the place of holes and 'fairways' narrowed by the buildings on either side.

But the first prize for craziest golf stunt ever must go to NASA astronaut Alan Shepard, on 6 February 1971. Shepard had been America's 'first man in space' in May 1961, but his achievement had been eclipsed by John Glenn's first orbital flight nine months later. The 1971 lunar mission, Apollo 14, would restore the shine of his reputation.

A lot was riding on the outcome of Apollo 14. The previous mission, Apollo 13, had nearly ended in disaster after a series of malfunctions. The Americans needed a success – and a scientific success for that matter – to justify the enormous sums being spent on the space programme. In the event, Shepard and his colleague Edgar Mitchell surpassed the tough goals set: they ventured further from the landing craft than any previous mission, spent more than nine hours exploring the surface and then collected nearly 50 kg of Moon rock.

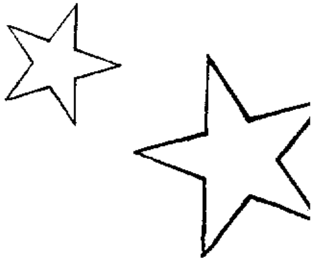
So perhaps no one back at mission control was too cross when Shepard took a break just before blasting off from the Moon's surface. He pulled out a modified (collapsible) six iron and two golf balls that he had sneaked inside his spacesuit. Then he whacked one after another into the lunar distance – 'for miles and miles and miles', as he noted aloud into his radio transmitter.

FOLLOW THAT STAR!

This book isn't all about quick-result, high-drama exploits. And if you're thinking of the heavens, you need to operate on a different timescale – one that uses light years and not minutes to get results. This experiment reveals an exciting and beautiful result but it takes its time to achieve it: one Earth year, to be precise. And the star that you'll be following through that time? Why, it's our Sun, of course.

YOU WILL NEED

- One nearby star (the Sun is ideal)
- A flat area (5 m square or more): smooth lawn is best, but a paved area will also do
- A strong pole at least 80 cm tall (or an existing pole secured in the ground and at least 50 cm tall)
- Mallet
- Spirit level or plumb line
- Tent pegs or paint
- Chalk or string (at least 10 m)



METHOD

1. Drive the pole into the ground so that it is secure and stands at least 50 cm tall.

2. Use a spirit level or plumb line to ensure that the pole stands straight.

3. Decide on what you will be using for the next year as markers on the flat area. Chalk is no good because it will wash away, so use either tent pegs (on lawn) or paint (on paved areas).

4. Note where the shadow of the pole appears at noon. Mark it with your permanent marker (peg or paint).

5. Continue to mark the noontime tip of the shadow at regular intervals – every week or two – for the next year.

6. Don't worry if you have a run of cloudy weather with no visible shadow – just resume when you can.

7. Draw the shape made by connecting the markers – with chalk (on paving) or by threading string through the tent pegs.

8. You should have produced a beautiful figure of eight.

THE SCIENTIFIC EXCUSE

It might have taken you a year, but you will have managed to demonstrate two important features of our planet. The long, figure-eight design that you plotted is called an analemma. The north-south difference of the points demonstrates the tilt of the Earth: the Sun (like its shadow) appears to move up and down through the seasons. The east-west differences are evidence that the Earth's orbit is an ellipse, and not a pure circle.

TAKE CARE!

You will have to ignore the change in clocks through the year for this one. In other words, if you begin the experiment in the winter (before clocks go ahead), take your reading at 1 pm (the same as noon, before the clocks went ahead) throughout the summer.

SOLAR-POWERED OVEN

These days everyone is talking about conservation and saving the environment. Recycling, alternative and renewable energy sources – these are all very good ideas. But what can we do as individuals to change our ways and help out? How about turning to our nearest star to lend a hand in the kitchen? But take note: you have to eat a pizza before starting out on this experiment.

YOU WILL NEED

- A large, recycled pizza box (the sort you get when you order a large takeaway pizza)
- Aluminium foil
- Black sugar paper
- Ruler
- Sheet of sturdy clear plastic (preferably laminated)
- Non-toxic glue
- Sticky tape
- Scissors
- Felt-tip pen

METHOD

1. Draw a border on the top flap of the pizza box, about 3 cm in from the edge.
2. Carefully cut along three of those four lines, leaving the line along the 'hinge' of the box alone. Open and close several times to form a crease.

3. Cut a piece of foil the same size as this flap; glue it to the inside (lower) edge of the flap.
4. Measure and cut a piece of plastic just a bit larger than the opening; tape this plastic to the underside of the box top, making sure it covers the cut-out hole to form a complete air seal. At this point, the box top should have this new plastic seal on the underside; the foil-backed flap opens up from this plastic layer.
5. Cut a second piece of foil and glue it to the bottom (inside) of the pizza box.
6. Cut some of the black sugar paper to fit this same base; tape it to the foil on the base.
7. Aim the box so that it opens towards the Sun.
8. Prop the flap open – but with the box top shut – to get the oven working.
9. You can cook all sorts of things – muffins, crumpets and maybe even more pizza – provided that they don't protrude higher than the box top.

THE SCIENTIFIC EXCUSE

The oven works by focusing the Sun's rays towards the food tray. The foil increases the number of rays entering the oven. They can pass through the plastic, but the heat stays inside. The result – evidence you can eat.

TAKE CARE!

Bear in mind that you have actually constructed an oven, which can reach temperatures of up to 135 °C. But it takes its time to reach that temperature. Leave half an hour for the oven to preheat, and then figure on cooking things for twice as long as you would in a normal oven.

BENDING LIGHT

What did Einstein say about light beams bending as they travel through space? He did mention drinks bottles, didn't he? Even if he didn't he should have, as you'll be able to show with this wonderful head-scratching display of wizardry. Make sure that when you've got everything prepared for the experiment, you really do turn off the lights in the room so that you'll get the best from this otherworldly demonstration.

YOU WILL NEED

- Empty 1-litre drinks bottle
- Torch (with its shining end about the same diameter as the base of the bottle)
- Aluminium foil
- Sticky tape
- Sink
- Audience

METHOD

1. Wrap a layer of foil around the outside of the bottle, leaving the top and bottom uncovered.
2. Secure this foil with tape if it seems a bit loose.

3. Fill the bottle with water and then tighten the cap. At this point you should make sure you are near the sink.
4. Position the torch snugly up to the base of the bottle.
5. Ask someone to turn off the room light and then turn the torch on.
6. Tilt the bottle down so that it's a little higher than parallel with the floor, and unscrew the cap.
7. Watch as the watery light beam escapes from the bottle and bends downwards into the sink.

THE SCIENTIFIC EXCUSE

This basic experiment demonstrates fibre optics, the process that allows photons (particles of light) to travel down a curving tube in the same way that a bobsleigh zooms through the curves of its run. How much of the light stays inside the tube and how much is reflected back depends on the angle of the light as it enters the tube. In this demonstration, the light from the torch travels along the tube because it reflects back from the foil. Better yet, it stays part of the 'tube' (this time reflecting back from the edge of the water itself) as it flows – and curves – down from the opening of the bottle.

TAKE CARE!

There's no danger in this experiment, but it works best with a powerful torch that is about the same size as the base of the bottle. That way, you get the most dramatic flow of photons with little or no light 'leakage' at the torch end of the bottle.

THE REVENGE OF ICARUS

And it is oh, so sweet! The ancient Greek lad got a little too close to the Sun, which led to his comeuppance. How about turning things on their head and actually using the same Sun to get a lift? Is this all just a lot of hot air? You decide. Just make sure you've chosen a calm, sunny day to try this out.

YOU WILL NEED

- Large black bin bag
- Twister seal
- String
- Paperclip
- Crayons
- Paper
- Scissors

METHOD

1. First of all, construct a fake £5 note (or other important document) by cutting a piece of paper and then colouring it in with crayon.

2. Hold the bin bag open with both hands and then whoosh it round until it is almost full of air.

3. Twist the top and seal it with string or a twister seal.

4. Tie a 2 m length of string to the knotted end of the bag and then clip the '£5 note' to the other end of the string.

5. Just wait. Depending on how warm it is outside, the bag will start to rise and then float up, up – and away, taking your money with it?

THE SCIENTIFIC EXCUSE

The Sun does all the work here. Its rays provide us with warmth anyway, but the black colour of the rubbish bag means that it absorbs even more heat. This warms up the air inside, which expands as it warms. But because the same amount of air now takes up more space, it loses density. And because the air inside is less dense than the outside air, it rises.

TAKE CARE!

This is a low- to no-risk experiment *unless* you decide to abandon the 'fake document' idea and use something that really is valuable.

IMPACT CRATERS

Everyone loves to make a little mess now and then. How about channelling this urge into something scientific and productive? This experiment reveals its evidence in one of the most babyish of settings – a sandpit. But what it tells us can help shed light on some of the mysteries of the heavens. Make a record of this experiment and you'll be on your way to mastering the scientific method.

YOU WILL NEED:

- Sandpit (the finer the sand, the better)
- Set of kitchen scales
- Notebook and pencil
- Ruler
- Five objects of different sizes and weights (for example a golf ball, a tennis ball, a marble and two stones)

METHOD

1. Smooth out the surface of the sandpit. This will represent the surface of Mars or the Moon.
2. Weigh each of the five objects and record that information.
3. Stand over the sandpit, holding the first object at arm's length, and let it drop down to the sand.
4. Measure the depth and width of the crater it produces.
5. Record this information.
6. Continue steps 3 ,4 and 5 for the other objects.

— THE SCIENTIFIC EXCUSE —

Each of the 'bowls' that forms is an impact crater. Bits of rock and ice are constantly flying towards Earth from outer space. Most of them burn up harmlessly in the atmosphere. But Mars has a much thinner atmosphere, and the Moon has none at all, so now you can see why their surfaces are so scarred. Don't lose your records: you can now draw conclusions about size, weight and the craters that are formed as a result. Next stop – the International Space Station.

TAKE CARE!

Remember that this is in the cause of science, and not Olympic shot-put trials. Simply *dropping* each object means that they fall at the same rate. If you started throwing some of them, you would be introducing what scientists call a variable – something that is different with each go. You don't want to lose your reputation as a precise scientist – you might lose millions in funding for your next project!

GENERALLY SPEAKING

Most people tend to study one scientific subject at a time when they are at school. Chemistry labs are full of Bunsen burners, test tubes, strange liquid mixtures bubbling away and students trying to decide what colour a piece of paper has turned. Biology and physics departments have their own look as well, what with diagrams of plant cells or inclined planes and stop-watches. But when 'things happen' in real life, you can't always pigeon-hole them. Nor can you package and store these experiments on a particular shelf, unless it's the one marked 'mayhem'.

BRIDGE OF SMOOTS

The Harvard Bridge spans the Charles River in Massachusetts where the river is at its widest, forming a basin that is a haven for sailing boats and rowers. On one side of the river is Boston, its old-and-new skyline forming a charming backdrop. On the other is the separate city of Cambridge, home of two of the world's great universities: Harvard and Massachusetts Institute of Technology (MIT).

The low-lying bridge offers excellent views of both cities, as well as the most direct way home for students after a night out in Boston. The only drawback is that it is long, and the late-night trudge home – often in the teeth of a howling blizzard – can seem endless. If only there were some way that walkers could keep track of their progress.

That aim – to provide evenly spaced markers painted on the bridge's pavement – prompted some MIT students to invent a new measurement in 1958. Oliver Smoot, a first-year student, was chosen to measure the bridge. More accurately, he was used to measure the bridge. Fellow students took the 1.7 m-tall Smoot and laid him on the pavement, moving him head over heels and then extending him again and again, all the way across the bridge. Smoot was chosen because his name sounded 'scientific', like 'watt' or 'amp'. Student volunteers painted coloured lines to mark every ten 'smoots'.

All of this would have been ancient history if the Massachusetts Department of Public Works had had its way in 1987, replacing the concrete with unpainted new slabs. There was an outcry in the local press, echoed by the Cambridge police (who used smoots as references for accidents on the bridge). In the end, the concrete was replaced, but in 1-smoot rather than the normal 6-foot (1.83 m) lengths.

MIT students continue to repaint the 10-smoot markers right to the Cambridge end, which is marked '364.4 smoots and one ear'. And what happened to Smoot himself? Well, in 2005 he retired from the board of the American National Standards Institute, which sets standard units for American industries.

MAD MOLECULES

This delightfully simple experiment can be used as a challenge or bet for a young audience. But before you smile at these confused youngsters with a superior air, you should remember that experiments such as this one helped open up our modern understanding of science. Since the mid-1600s, some of the greatest names in science – including Robert Boyle, Antoine Lavoisier and John Dalton – have devoted themselves to this area of science. You can simply reap the results of their labours, and win the occasional bet as a result.

YOU WILL NEED

- 2 small mixing bowls
- Hot water
- Cold water
- Food colouring
- Young audience

METHOD

1. Fill one bowl with hot water and the other with cold.

2. Put the bowls side by side.

3. Ask your audience to predict what will happen if you add a drop of food colouring to each bowl.

4. Challenge anyone who says 'it will look the same for both' to a bet.

5. Add the drop of food colouring to each bowl.

6. Note how the food colouring in the hot water fans out rapidly, while the one in the cold stays pretty much the same.

7. Collect your winnings.

THE SCIENTIFIC EXCUSE

As substances warm up, the molecules making them up do so become more excited (they move around more). That means that the hot water molecules are more active than the cold ones, which is why they take the colouring for a ride around the bowl. But it was looking in the other direction – to see whether there is a point where things are so cold that nothing moves – that occupied those great scientists. And indeed there is: absolute zero (minus 273 degrees Celsius, or minus 459 degrees Fahrenheit).

TAKE CARE!

Make sure none of the younger children dips a hand in the hot water.

PAPER SAUCEPAN

Who in their right mind would set about cooking with paper over an open flame? An irresponsible cook, obviously. Just ask any of your friends. Ask them another question, though: would it still be *possible* to boil water in a paper cup over an open flame? Here's a demonstration of how you can silence the doubters.

YOU WILL NEED

- Paper cup (must be unwaxed)
- Eight red builder's bricks
- 60-cm string
- Short candle
- Water
- Fork or knife (to poke holes in the cup)
- Matches or lighter

METHOD

1. Poke two small holes opposite each other near the top of the cup.
2. Thread the string through the cup so that there is a similar amount on each side of it.
3. Make two piles of four bricks, about 40 cm apart.
4. Suspend the cup between the brick piles, anchoring it in

place by sandwiching the string between the third and fourth courses of bricks.
5. Knot the string on the outside of each brick tower, so that the string remains taut.
6. Position the candle below the cup with about a 5cm gap between the wick and the base of the cup.
7. Fill the cup about three-quarters up with water.
8. Light the candle.
9. The water will heat up and eventually boil – but the paper cup won't catch fire!

THE SCIENTIFIC EXCUSE

For paper – or anything – to burn, it must warm up to its auto-ignition temperature, or 'kindling point'. Put simply, that is the lowest temperature at which a solid will spontaneously combust. A candle's flame would normally be enough to reach that temperature for paper, but the water draws heat away from the paper, keeping the paper below its kindling point while the water itself heats up to boiling point.

TAKE CARE!

This experiment is all about heat passing through the paper to the water that will absorb it, so you must not use a wax-covered paper cup. Why? Because the wax will absorb the heat as much as the water does, but in a much smaller (and therefore easier to heat up) volume ... increasing the chances of the paper itself catching fire.

MATCH ALERT!

This experiment involves the use of matches and should only be conducted by a responsible adult.

– THE –
DISAPPEARING
BEAKER

This experiment is so – dare we say it? – reliable and easy to perform that it demands an audience. Who could possibly misplace a graduated beaker inside another one? But there's no getting around the fact that the smaller one really did go inside the larger one, and no one took it out. And it's nowhere to be seen. Hmm.

• YOU WILL NEED •

- 400 ml cylindrical glass beaker
- 250 ml cylindrical glass beaker
- Bottle of glycerine (sold as a throat soother)

METHOD

1. Put the smaller beaker inside the larger one.
2. Show the beakers to your audience (the smaller beaker should be easily visible).
3. Fill the gap between the beakers with glycerine.
4. The smaller beaker will have disappeared!

THE SCIENTIFIC EXCUSE

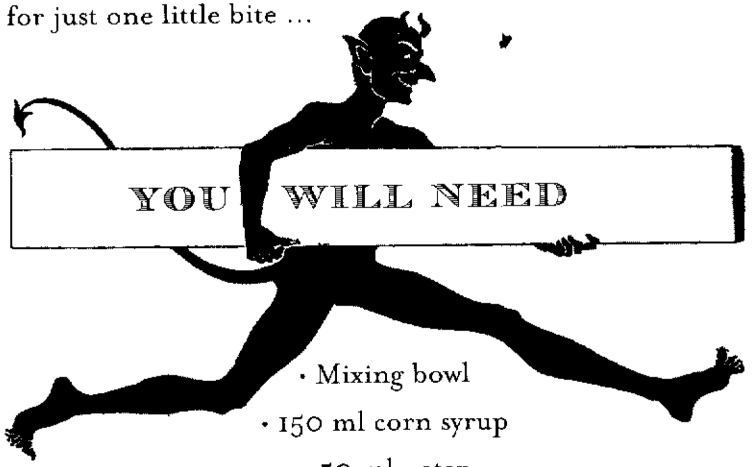
This experiment is all about refraction, the process by which light waves bend as they pass through different substances. Refraction can be measured, and the result is called the refractive index of the substance. The glycerine and the glass have very similar refractive indices, which means that light passing through the glass continues straight through the glycerine. The same trick would not work with water between the beakers, because its refractive index is different from that of glass – making the other beaker clearly visible. Likewise with air, as you saw before you added the glycerine.

TAKE CARE!

Make sure you use glass beakers of the cylindrical shape, not the cone-shaped beakers with the narrow tops.

DRACULA'S COCKTAIL

'Just one draught of this lovely liquid and I feel I could sleep for eternity.' You might imagine Dracula himself uttering those words if you master this do-it-yourself blood exploit. It's fun trying to match your kitchen ingredients to a vampire's menu, but even more fun if you take things further and actually drink from the goblet. Ahh, now time for just one little bite …



YOU WILL NEED

- Mixing bowl
- 150 ml corn syrup
- 50 ml water
- 5 tbsp cornflour
- 4–5 tsp red food colouring
- 2–3 drops of green food colouring
- Wine glass (optional)

METHOD

1. Mix the cornflour thoroughly with the water.

2. Add the corn syrup and stir well.

3. Stir in 3 tsp of red food colouring.

4. Add 2 drops of green food colouring.

5. Check on the colour of the 'blood': if it is too light, add one or two more tsp of red colouring. Add another drop of green if it is still a little pink.

6. The 'blood' is ready. You can pour some into the wine glass and have a Dracula cocktail.

THE SCIENTIFIC EXCUSE

There's no mysterious science at work here; only household ingredients mixed to get the right colour and consistency of the real thing. Bear in mind that real blood is a little darker (browner) than you might think, so don't go for pure red.

TAKE CARE!

You'll have enough explaining to do anyway ('why is there blood all over the place?'), so don't add to your worries by getting any clothes or furniture stained.

– The –
Unbalanced Balance

On balance, this is one of the most eye-catching experiments that you will ever perform. What's more, it cries out for an audience. And like a champion boxer, you'll be packing a one-two punch. The first is getting the 'mating forks' to balance on a toothpick. But the real knockout is burning away that toothpick to nothing ... and keeping the forks balanced in mid-air!

YOU WILL NEED

- 2 forks, or a fork and a spoon
- Toothpick
- Heavy-bottomed drinking glass

METHOD

1. Link the forks together by weaving their tines (this takes a little practice and might be easier if you use a fork and a spoon).

2. The handles should be pointing away from each other, not quite forming a straight line (more like a broad 'V').

3. Work the toothpick into the junction of the two forks until about 5–10 mm emerges from the back of the forks.

4. Balance the forks/toothpick combination on the rim of the glass. This also takes a little practice but it can be done. The point of the fork 'V' is suspended outside the glass with the two arms extending inward. About half of the toothpick juts into the inside of the glass.

5. Light the tip of the toothpick that is inside the glass.

6. The toothpick will burn away until it reaches the rim.

7. No part of the toothpick extends in over the glass anymore, but the forks will remain balanced!

— THE SCIENTIFIC EXCUSE —

This outlandish gravity-defying display depends on the notion of centre of gravity. Think of how a tightrope walker remains balanced so high above the circus Big Top. The chances are that he makes his way along the wire while holding a long pole. The fork combination itself, rather than the toothpick, acts as the tightrope walker's pole – providing balance in the unlikeliest circumstances. Even when the toothpick has largely burned away, there is still a very small point on which the arrangement rests. Why does the burning stop when it reaches the inside rim? Probably because the glass absorbs the heat and lowers the temperature.

MATCH ALERT!

This experiment involves the use of matches and should only be conducted by a responsible adult.

THE FINGER OF FATE

Are you looking for another one of those quick 'how in the world?' demonstrations? A quickie that demonstrates your supernatural powers – or maybe your superhuman strength? Now read on. And while we're on the subjects of commands: don't get up until I say so. Is that clear?

YOU WILL NEED

- Willing volunteer
- Upright chair

METHOD

1. Have your friend sit in the chair with good posture – head back and chin up.

2. Put your index finger up to his forehead and press lightly but firmly.

3. Ask your friend to get up.

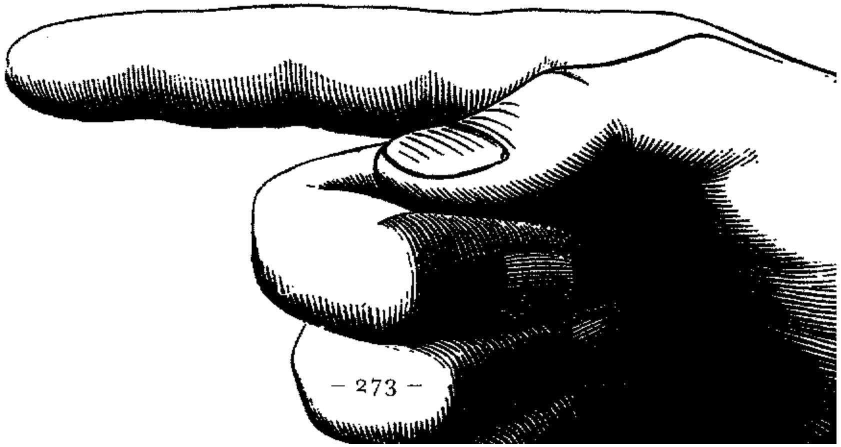
4. He won't be able to stand, or even move very much.

THE SCIENTIFIC EXCUSE

You might well have supernatural powers or superhuman strength, but you won't need either of them for this experiment. It's all down to centre of gravity, or, more accurately, centre of mass. That is the point at which the mass of an object seems to be concentrated (it's also part of the secret of tightrope walkers). The centre of gravity of a seated person is the chair. In order to stand, the person must move that centre of gravity over the feet. And the first step for that to happen is to move the head forward. But even the slight force of your fingertip is enough to keep the cards stacked against the person moving out and up. Your friend stays put.

TAKE CARE!

There's no danger here – just the usual warning about not overplaying your hand and getting on your victim's nerves.



ANTI-FLAME THREAD

Scientists often get the best results when they seem to be confounding nature – lids not falling off when they should, foam bubbling up out of nowhere, pepper obeying their commands. This experiment falls into that category, and you'll soon see why! Bear in mind, though, that it calls for extremely calm conditions, so it is best done indoors. If you do plan to do it outside, make sure you have chosen a day with no wind and that you're shielded from even the slightest breeze.

YOU WILL NEED

- Cotton thread
- Wine cork
- Knife
- Matches
- Wooden rod or pole (about 1 m long)
- 3 tsp salt
- Water
- Small bowl

METHOD

1. Cut about 40 cm of thread.

2. Half-fill the bowl with water, add the salt and stir it in until it dissolves.

3. Soak the thread in the salt solution and then take it out to dry.

4. Repeat step 3 about three more times.

5. Cut notches in the cork and tie one end of the thread to it.

6. Rest the long rod or pole across two chairs or between a chair and a counter.

7. Tie the other end of the thread to the rod. The cork should be hanging down from it.

8. Light the thread at the lower end, near the cork.

9. The thread will burn away, leaving a thin trail of ash. But this ash is still holding the cork up!

THE SCIENTIFIC EXCUSE

You alone know that although the cotton thread has burned away, the cork is still held up by a column of salt that runs the length of the thread. It is strong enough to withstand the pull of the cork, but a slight breeze would break this magic chain.

TAKE CARE!

Make sure you don't perform this experiment near to anything that could be damaged by flames.

MATCH ALERT!

This experiment involves the use of matches and should only be conducted by a responsible adult.

RULE(R)S ARE MADE TO BE BROKEN

Students in some schools traditionally break their rulers at the end of their last day at school. In no way does this book encourage such wilfully destructive behaviour. It does, however, encourage the spread of knowledge and scientific curiosity. That means it's all right to break not just one ruler, but maybe even two.

YOU WILL NEED

- 2 rulers, preferably wooden (which will be broken)
- Empty golden syrup tin (with its metal lid)
- Strong tape
- Blu-Tack
- Metal bottle cap (from a drink needing a bottle opener)
- Volunteer
- Water

METHOD

1. Fill the tin to overflowing with water and fix its lid back on tightly.

2. Fix the bottle cap to the top of the lid (right-side up) with a little Blu-Tack.

3. Put one ruler on the counter and centre the tin on it.

4. Rest the second ruler across the top of the tin (directly above the first ruler) and secure it with more Blu-Tack.

5. Have a volunteer hold this combination up and loop the tape tightly around the rulers. You should have a loop at each end, tightly pulling the rulers towards each other.

6. Put this set-up in the freezer and wait 24 hours.

7. Open the freezer and note how the top ruler has been broken; the bottom one might also be broken.

THE SCIENTIFIC EXCUSE

Most chemical substances contract (become smaller) as they cool. Water is no exception, until it starts to get close to freezing point (0 °C). That's when it seems to march to the beat of a different drum and begins to expand. By the time it is a solid (ice) it takes up more volume – enough to push the lid out until it breaks free of the ruler binding it.

TAKE CARE!

It should be obvious, but make sure that the rulers you use in this experiment are your own, and that you can live without them.

SKIM READING?

Wouldn't you love to be able to walk into a room, pick up the first couple of things that came to hand and then demonstrate some astounding scientific principle? This experiment – or demonstration – falls into that category. It's what you might call a slow-burner: why not keep it in mind so that next time you walk past a friend's bookshelf, you can dazzle them.

YOU WILL NEED

- 2 paperback books of about the same size and number of pages

METHOD

1. You're aiming to 'lock' the books together by having their pages overlap each other.

2. Put the books on a table, facing each other so that their open-pages sides just touch.

3. Lift each book up by the open-pages side, so that the spines stay on the table but edge closer to each other by about 3 cm.

4. Rifle through the pages with your thumbs (from the back of the book to the front).

5. If you've managed to do this right, the pages of the books will overlap each other by the same 3 cm.

6. Try to pull the books apart. It seems as though they're locked together.

THE SCIENTIFIC EXCUSE

This experiment works thanks to friction, the force that acts as a brake against things sliding apart. Each overlap is a source of friction, but multiplying that force by 50, 60 or however many overlaps you manage to produce will increase the force a great deal. No sweat.

TAKE CARE!

No real problems here – except don't use someone's priceless first edition (even if it is a paperback).

EDIBLE CRYSTALS

Every science book needs to be able to lighten some of the theoretical content one way or another. It could be with groan-inducing puns (we plead guilty), outlandish or unexpected results (guilty again, your honour), or letting you eat the fruits of your labours. And that's where this excellent introduction to crystals comes in. Come and crunch away on some sweet science.

YOU WILL NEED

- 150 g sugar
- 200 ml water
- Saucepan
- Wooden spoon
- Heatproof bowl
- Pencil
- 40 cm length of string

METHOD

1. Bring the water to the boil in the saucepan.

2. Add the sugar and stir while the sugar dissolves.

3. Pour this mixture into the bowl.

4. Tie one end of the string to the pencil and let the other end dangle in the sugar-water solution.

5. Keep the pencil supported with books on either side while the string continues to hang down into the bowl.

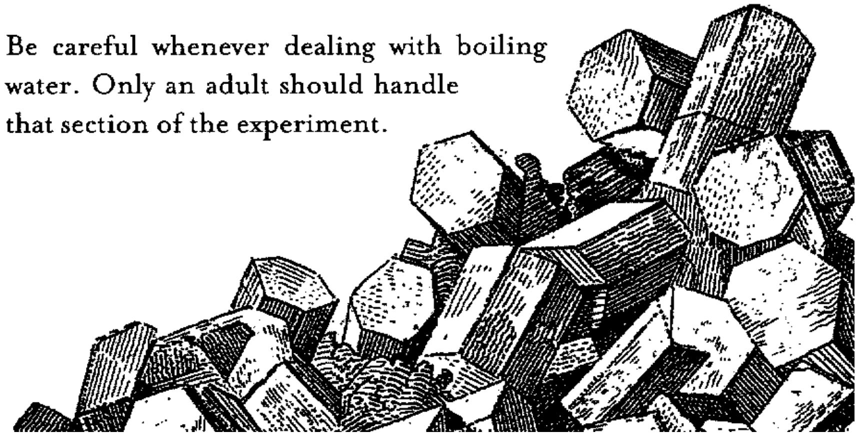
6. Within a few days crystals will begin to form on the string.

THE SCIENTIFIC EXCUSE

The science is simple enough in this easy-to-manage experiment. It's all about solutions. The sugar dissolves (goes into solution) thanks to the heat and with a little help from your stirring. Then the liquid travels up the string through the process called osmosis – the same way plants suck water from the soil. Then the water evaporates, leaving the solid sugar crystals – no longer in solution – there to be plucked from the string.

TAKE CARE!

Be careful whenever dealing with boiling water. Only an adult should handle that section of the experiment.



SALOON BRAWL PROP

Wouldn't it be wonderful to have some of the props that Hollywood directors have at their disposal? Not CGI effects, which soon seem artificial. More like something that you could use to hit a real person over the head, and then see shatter (the prop, not the head). This demonstration helps you do just that – you'll cook up a batch of realistic glass or ceramic tiling. Whatever cinematic role the end result plays, it will smash to smithereens when it is slammed into someone's head. Lights, camera, action!

YOU WILL NEED:

- 200 g sugar
- Saucepan
- Baking sheet (small enough to fit in a refrigerator)
- Butter
- Wooden spoon
- Spatula or slice

METHOD

1. Use butter to grease the base of the baking sheet.

2. Put the baking sheet in the refrigerator.

3. Pour the sugar into the saucepan and put it on the stove to heat gently.

4. Stir the sugar frequently as it warms and cooks.

5. When the sugar has melted, and before it begins to change colour, get the baking sheet out and pour the melted sugar onto it.

6. Shape the still-liquid sugar into squares and rectangles with the spatula or slice.

7. Leave the tray to cool on a counter.

8. In about an hour, it will have hardened and become brittle – ideal for filming that brawl at the local saloon.

THE SCIENTIFIC EXCUSE

There's no surprising science at work in this experiment, just sugar molecules melting as they are heated and then becoming solid once more when they cool down again.

TAKE CARE!

There's no real danger arising from this deceptive trick, but never use the 'glass' to hit anyone on the face – just the back of the head, as in the movies.

CLIFFHANGER ENDING

Here's an experiment that you could do in the classroom, ideally while waiting for your English teacher to arrive. You'll find that it works best with a lot of identical books, and what better place to find identical books than in an English lesson, if you're all reading the same set text? And if your teacher arrives in the middle of this demonstration? Simple – just tell her that you are seeing whether or not the book really is a cliffhanger.

YOU WILL NEED

- 6 identical books (not too thick)
- Level desk, counter or table

METHOD

1. Arrange the books in a neat pile at the edge of the desk, with the narrow sides of the books along the edge.

2. Slide the top book out slowly until it teeters on the pile, then slide it back a little.

3. Move the second book out (with the top book still on it) until they both teeter, then slide them back a bit.

4. Continue this until you have moved every book.

5. When you finish, the top book will appear to be suspended in mid-air, like a cartoon character who has just run off a cliff and is about to fall.

THE SCIENTIFIC EXCUSE

You've just demonstrated the centre of gravity (or centre of mass), the 'concentration point' of the overall weight, where the whole arrangement balances. Although the top book seems as though it should be about to plummet, more than half the weight of the books supporting it is safely on the desk.

TAKE CARE!

Just make sure you choose the right books, and the right teacher. A good sense of humour is a help (for the teacher, that is).

CREATE A FOSSIL

Every so often, a TV chef will pull out a lovely roast chicken or a bubbling curry from off-camera and say 'Here's one I started earlier'. It makes sense: after all, you can't watch the television for the entire six hours it takes to cook a turkey. But how would you feel if you could say 'Here's one I started about 40 million years ago'? That might make your audience stop in its tracks. And you'd only be stretching the truth a little bit. You've been recreating all the stages involved in turning something into a fossil and just given them a little nudge.

YOU WILL NEED

- Pack of bath salts
- Warm water
- Small baking tray
- Bath sponge
- Fine sand (sandpit sand works well)
- Cup
- Empty plastic margarine tub
- Knife
- Scissors

METHOD

1. Use the scissors to cut the sponge into a three-dimensional shape that will become the fossil: it could be in the shape of a dinosaur bone or tooth, or maybe even a primitive shellfish. Make sure the finished product can fit easily into the tub.

2. Make a few small holes in the bottom of the tub and rest it on the tray.

3. Fill the tub with a 1–2-cm layer of sand, and then lay your sponge 'fossil' on it.

4. Cover this with another 3-cm layer of sand.

5. Mix 4 tbsp of warm water with 4 tbsp of bath salts in the cup; pour this mixture over the sandy tub, letting the liquid sink through the sand.

6. Leave the tub in a warm place, such as the bottom of the airing cupboard or a sunny windowsill, for five days.

7. Repeat step 5 for each of those days.

8. Leave the tub without adding any more liquid for another two days.

9. Carefully remove your fossil, which should be very hard by now.

THE SCIENTIFIC EXCUSE

Sponge, as we all know, absorbs a great deal of water. The salty liquid seeps through the sand, being collected by the sponge on its way down and then being sucked back up from the tray by the process called osmosis. Then it evaporates, only to be topped up every day by you. Each time the water evaporates, it leaves some of the salts that were in solution with the water. Each 'dose of salts' hardens the fossil a bit more, until it really does look 40 million years old.

TAKE CARE!

If your fossil still feels a little pliable, leave it to dry for another day.

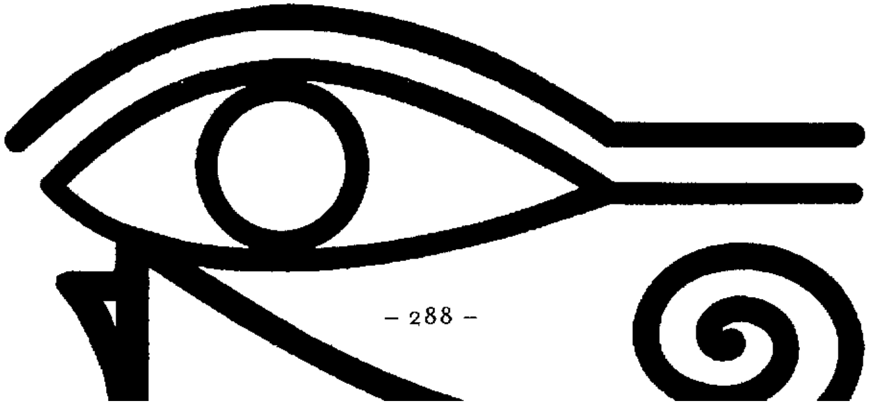
PHARAOH'S SECRET

If you found that your house contained some fossils dating back millions of years (see 'Create a fossil', page 286), why shouldn't it contain some equally mysterious messages from only about 4,000 years ago – from ancient Egypt, perhaps? How is it that no one knew about these secrets? Who can unravel them? Only you have the answers, and the skills to penetrate these mysteries.

◆

YOU WILL NEED

- Half a lemon
- Egg cup
- Toothpick or fountain pen
- Candle
- Piece of ordinary writing paper (the older-looking the better)



METHOD

1. Squeeze the juice of the lemon half into the egg cup.

2. Write a message using ancient Egyptian symbols, known as hieroglyphs, on the piece of paper.

3. Pass the paper to your archaeologist partner, and see if he or she can read it. The lemon juice will have evaporated and the paper will look untouched.

4. Light a candle and hold the back of the paper close to the flame, but not too close.

5. The ancient message – the Pharaoh's secret – will be revealed as a brown ink message.

THE SCIENTIFIC EXCUSE

The evaporating lemon juice that left no visible trace is just part of the secret. But it leaves behind citric acid, which has a lower ignition temperature (it gets ready to burn, turning brown) than the neighbouring paper. That is why the message 'burns' its way through.

TAKE CARE!

Don't rush and get the paper too close to the flame; be patient and edge it closer until the message appears.

MATCH ALERT!

This experiment involves the use of matches and should only be conducted by a responsible adult.

CASH AND CARRY

'He demanded the ransom in cold, hard cash.' 'That money seems to be burning a hole through your pocket.'

The English language is full of expressions linking money with temperature. Why is that? And why do these expressions contradict each other? Is there any way of performing a test on some money to get to the root of all this?

This experiment should shed some light on why we think of money in the way we do. The results might surprise you.

YOU WILL NEED

- Loose blindfold (a large handkerchief will work)
- 2 identical coins (British 10 p coins work well)
- Ice cubes or a freezer
- Towel
- Volunteer

METHOD

1. Blindfold your volunteer and tell him that he is going to be a human set of scales.

2. Have him put his arms out with palms up and middle and index fingers outstretched.

3. Put a coin on each pair of outstretched fingertips and ask him to decide which weighs more. He should say that they weigh the same.

4. Put one of the coins on an ice cube or in the freezer for two minutes and then dry it quickly with the towel. Don't tell your volunteer what you are doing.

5. Tell your 'scales' that you have two other coins to weigh (they are, in fact, the same two coins).

6. See which of this pair seems heavier. He will probably say that the colder one does.

THE SCIENTIFIC EXCUSE

This simple experiment actually has a mystery at its heart. Scientists aren't exactly sure why colder objects feel heavier than warm ones. One theory is that the nerve endings that detect changes in weight are also used to detect changes in temperature and that the result is something of a 'short circuit'.

TAKE CARE!

This is in competition for the least risky experiment in the book.

SCRAMBLED BED

You've had a run of wet weather and your mum has only now managed to get the sheets dry on the line outside. What can you do to help? How about showing off a bit of physics by making one of the sheets a target and hurling an egg at it? It's perfectly safe, of course. Admittedly, you might lose your nerve once you get the clean sheet unfurled, worried that you might wind up with egg on your face. Read below for a safe way to practise.

YOU WILL NEED

- Egg
- Bed sheet
- Golf ball (optional)
- Two volunteers

METHOD

1. Have your volunteers hold the sheet so that there is enough slack to make a trough.

2. Pick up the egg and take aim at the trough of the sheet.
3. Throw the egg as hard as you can.
4. The egg won't break.

THE SCIENTIFIC EXCUSE

You could produce a wonderfully long and complicated equation to explain this experiment, but the basic principle is simple. If you increase the amount of time needed to stop a moving object, you need less force to do so. Even the extra tenth of a second or so that you give the egg – compared to hitting an unyielding solid object – is enough to let the sheet gently ease it to a standstill. Think of a car approaching a red light. The driver could simply tap the brakes gently for perhaps ten seconds, or jam them on hard at the last instant. Which do you think needs more energy?

· TAKE CARE! ·

There's no need to remind anyone about the consequences of breaking an egg on a freshly cleaned sheet. You needn't really worry about that, but if you're feeling a little edgy you can practice a few times using a golf ball instead of an egg. Which comes with its own warning: don't do it anywhere near a window.

FOAMING FINALE

This experiment comes in at the very end for a good reason – it is the only one that also allows you and your crew to clear up afterwards. You could even say that the whole point of the experiment is to find a way of cleaning up after the experiment. Is that getting a little too confusing? Well, read on and prepare to do some scrubbing.

YOU WILL NEED

- Drinking glass
- Half a lemon
- Lemon squeezer
- Spoon
- Washing-up liquid
- 1 tsp bicarbonate of soda

METHOD

1. Add the bicarbonate of soda to the glass.

2. Squeeze in a good dollop (about 2 tsp) of washing-up liquid and stir.

3. Squeeze the juice from the lemon half.

4. Pour the lemon juice into the glass. Begin stirring.

5. Remove the spoon and observe the foam brewing up.

6. Stir some more to produce even more foam, which should start to ooze out over the edge of the glass.

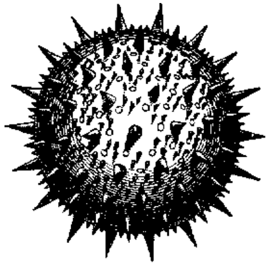
7. Use the lemon-scented soapy foam to clean up your lab.

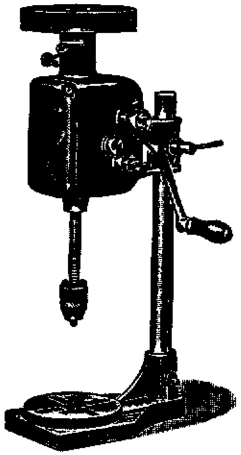
THE SCIENTIFIC EXCUSE

At its core, this experiment relies on an old standby – the reaction between the bicarbonate of soda (an alkali) and the citric acid of the lemon. When these combine, just like the combination of vinegar (another acid) and bicarbonate of soda, one of the by-products is carbon dioxide. And it's the CO_2 that keeps bubbling up.

TAKE CARE!

How can you possibly get into trouble when you've promised to clean up after yourself?





AT A GLANCE

Some of the 120 experiments in this book can be done almost in an instant; others take up to several days to achieve their dramatic effect. The following list groups them in order of time taken, starting with those that can be done most quickly.

FLASH IN THE PAN

less than 2 minutes

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EXPERIMENT DIARY

NAME OF EXPERIMENT:

DATE:

WHERE CONDUCTED:

WEATHER CONDITIONS:

WITNESSES:

DESCRIPTION OF EVENTS AND REACTION:

GOT INTO TROUBLE?

EXPERIMENT DIARY

NAME OF EXPERIMENT:

DATE:

WHERE CONDUCTED:

WEATHER CONDITIONS:

WITNESSES:

DESCRIPTION OF EVENTS AND REACTION:

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